Tropical Water Quality Hub
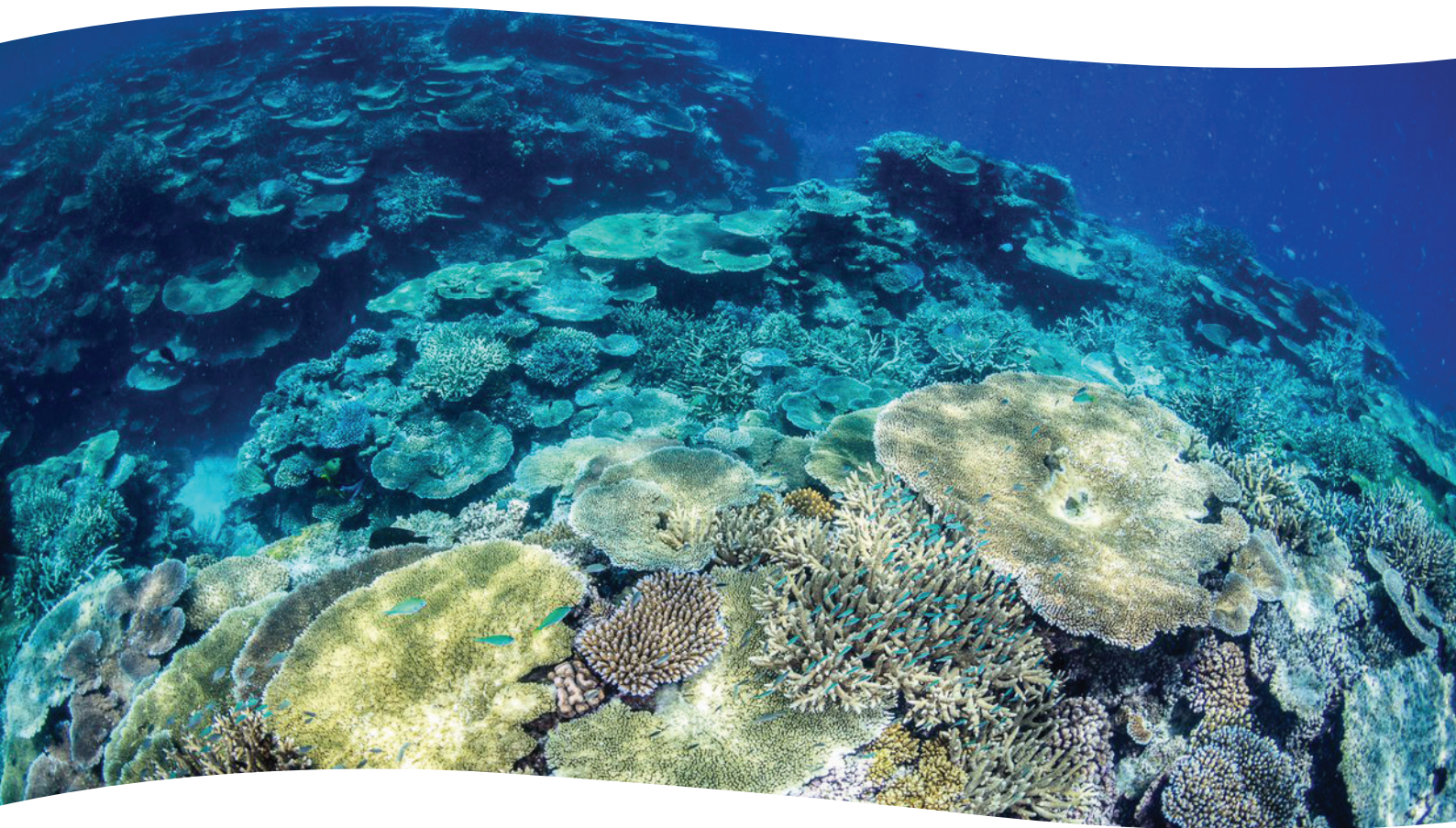
National **Environmental Science** Programme

A Cross-Cultural Investigation of the Great Barrier Reef Aesthetic Values

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ACRONYMS

AI .... Artificial Intelligence
ALTMP.......... Aesthetics Long-Term Monitoring Program
CSIRO........... Commonwealth Scientific and Industrial Research Organisation
GBR .... Great Barrier Reef
GBRMPA ...... Great Barrier Reef Marine Park Authority
NESP .... National Environmental Science Program
OUV .... Outstanding Universal Value
QTIC .... Queensland Tourism Industry Council
RRRC........... Reef and Rainforest Research Centre Limited
SELTMP .... Social and Economic Long-term Monitoring Program
TEQ.............. Tourism and Events Queensland
TWQ............. Tropical Water Quality
UNESCO....... United Nations Educational, Scientific and Cultural Organisation

ACKNOWLEDGEMENTS

EXECUTIVE SUMMARY

The Great Barrier Reef (GBR) is listed as a World Heritage site by UNESCO due to its Outstanding Universal Value (OUV), of which one component is its natural beauty and aesthetic value. The GBR is a major drawcard in attracting visitors to and from within Australia and it provides important social, economic, and recreational benefits to Reef users and local communities. However, GBR aesthetic values have been recently threatened by environmental changes (e.g., runoff and sedimentation, increases in ocean temperatures, and acidification). The Australian Government has invested considerable resources into improving environmental management practices and protecting the unique biodiversity of the Reef. Previous reports (the 2013 Context Report, two GBR Outlook Reports 2014, 2019) provide relevant background on environmental conditions of the GBR and give some insights (directly or indirectly) into the aesthetic value of the Reef.

Two earlier NESP-funded projects (3.2.3 & 3.2.4) conducted research specifically on perceptions of Reef beauty. Both of the earlier projects drew on a representative sample of the Australian population and established key environmental attributes that influence aesthetic perceptions. The studies also identified some differences in aesthetic perceptions between various Reef user groups. The research designs, however, did not specifically allow for cross-cultural comparisons. Therefore, aspects of the human dimensions of the GBR aesthetics remain underexplored. The current research aims to address this knowledge gap and advance our understanding of how different users perceive the aesthetic value of the under-water Reef environment.

Three Reef user groups with different socio-cultural backgrounds were recruited: Chinese people as an important economic international visitor group, First Peoples and non-Indigenous Australian citizens. The user groups were involved in two separate but complementary studies: an exploratory qualitative study with focus groups, followed by a confirmatory quantitative study using eye-tracking, face-reader and self-report survey. In study 1, 29 participants representing the three Reef user groups were recruited for focus group discussions. Then 93 participants were involved in study 2, generating quantitative data to statistically verify the socio-cultural influences on aesthetic assessment of GBR scenery.

Main insights from this mixed-method research include:
1. Evidence of a dual-perceptual approach to aesthetic assessment of natural environments (see Figure 18), whereby human aesthetic appreciation is constructed from two distinctive and complementary perceptual layers: (1) an objective layer based on cognitive recognition of environmental characteristics, which were similar across all three user groups, and (2) a subjective layer based on the decoding of socio-cultural meanings attached to the environment, which leads to some variations aesthetic assessment among three Reef user groups.
2. Demonstrating the relative contributions of these two perceptual layers to the overall aesthetic assessment of the GBR underwater aesthetics. The objective layer shapes the overall aesthetic assessment of underwater GBR environments, compared to the subjective layer. Despite their socio-cultural backgrounds, three groups shared a similar aesthetic order of five environmental conditions of the GBR. The subjective layer causes some variations (less than 10%) in the aesthetic ratings

among three groups toward the extreme end of aesthetic spectrum (highly aesthetic areas and polluted areas), but no significant differences in three other environmental conditions (medium aesthetic areas, coral restoration sites and degrading areas). First Peoples tended to use the extreme points of the beauty scale more frequently: they gave the highest scores for highly aesthetic sceneries of the GBR and the lowest scores for polluted sceneries compared to two other groups. This could be partly explained by First Peoples' natural connection with the Reef and cultural significance of the GBR.

3. Testing the usefulness of some advanced research technologies (i.e., eye-tracking, face-reader). This study confirms initial findings from NESP TWQ 3.2.3 that eye-tracking is effective in measuring visual attention and interest in natural environments, which partly reflect aesthetic assessment. Eye-tracking could also be beneficially used in real-life conditions such as exhibitions, museums or landscapes to help understand aesthetic experiences. Also, face-reader provides consistent measurements of emotional valence (positive versus negative) when comparing emotional responses of the three groups toward the GBR tourism promotion video. Face-reader might be employed as an additional measurement of emotions in future research.

4. Recommending practical implications to effectively manage the GBR aesthetics, possibly with the aim of increasing interest and support for environmental action. We recommend that aesthetic monitoring can rely on a 10-point beauty scale across different user groups (noting adequate sample sizes). This could be done manually or using an Artificial Intelligence-based aesthetic monitoring system. Some consideration needs to be given to social-cultural influences, especially at the two end points of the spectrum. First Peoples' perspectives are central to all communications pertaining to the cultural significance/authenticity of GBR aesthetics, as well as to enhance public support for conservation efforts. Finally, the research provides specific insights for targeting communication at the different user groups, for example, with a particular focus on safety in the case of Chinese Reef users versus emotional appeals in case of Australian users.

In summary, this report explores whether and how socio-cultural characteristics might shape the perception of under-water Reef beauty and thus advances our understanding in this area. Research outcomes show that the objective layer based on environmental characteristics makes superior contributions to the overall aesthetic assessment of the GBR underwater scenery compared to the subjective layer based on socio-cultural meanings. Therefore, an (AI or manual) aesthetic monitoring system developed from learning the average aesthetic score of one user group (e.g., Australian user) can provide sufficiently robust aesthetic ratings for a broader range of Reef user groups.

1.0 INTRODUCTION

1.1 About this report

This report presents findings from Project 5.5 funded under the NESP Tropical Water Quality Hub (TWQ). Project 5.5 focuses on understanding and measuring two key concepts relevant for ongoing Reef protection, namely the (underwater) aesthetic value and the experience value of the Reef (Figure 1). While it is likely that changes to the aesthetic value affect visitor experience and sentiment, it is useful to capture these constructs separately. The reason being that visitors to the Reef, at least for some groups, continue to have enjoyable experiences, even in the face of ongoing decline in Reef health and apparent aesthetic value.
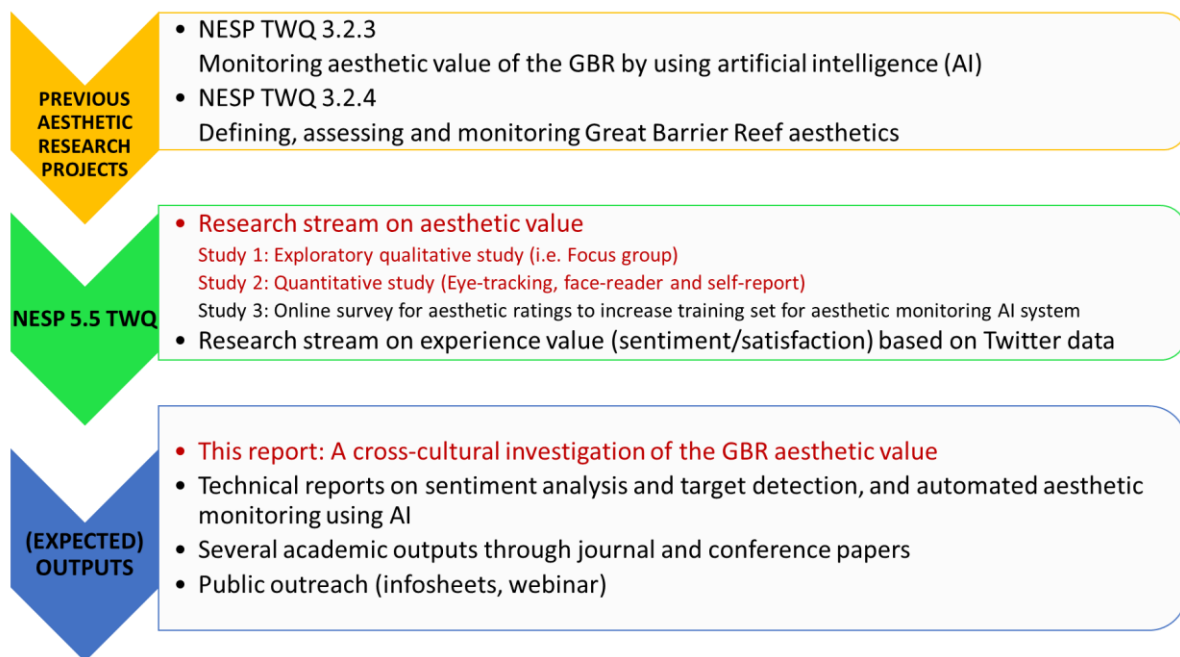
Figure 1: Project framework (in red the components presented in this report)

Some parts of Project 5.5 are presented in separate publications, including a technical report on sentiment analysis and target detection in social media text (Stantic, Mandal, & Chen, 2020); a technical report on the advanced aesthetic monitoring AI (in preparation), and a conference paper that discusses how to integrate social sciences research with AI (Le, Becken, Stantic, & Mandal, 2020).

This report presents findings from two studies of the research stream on the aesthetic value, which aim to examine potential socio-cultural influences on aesthetic assessment among three different user groups: First Peoples, non-Indigenous Australian citizens, and Chinese visitors. The reason for choosing these three user groups was to capture potential differences between First Peoples (who have an innate cultural attachment to country compared to other Reef users), non-Indigenous Australian citizens and Chinese visitors as a key visitor group of growing economic significance to Australia. The two studies both address the overall aim of understanding cross-cultural differences in the ways Reef user groups perceive and make sense of the GBR aesthetic value. Study 1 is an exploratory qualitative study using focus groups to verify key aesthetic attributes of the GBR that have been identified in previous research projects (NESP TWQ Hub Projects 3.2.3 & 3.2.4) and additional socio-cultural

attributes. Study 2 consists of a confirmatory quantitative study using innovative technologies (i.e., eye-tracking, face-reader) in combination with a series of closed questions that enable statistical testing of socio-cultural influences on aesthetic perceptions.

1.2 Research context

The Australian Government is investing considerable resources into improving Reef health and monitoring environmental change within the GBR. While the link between ecosystem integrity and aesthetic value remains underexplored, it is likely that regeneration of Reef health will have associated benefits in relation to its outstanding beauty (Marshall, Marshall, & Smith, 2017). The Reef aesthetics are threatened by a wide range of pressures and environmental changes, including the impacts of rising sea temperatures (leading to coral bleaching), degradation of water quality and acidification (Hughes, Kerry, & Simpson, 2018; Marshall et al., 2019).

Natural environments are known to have restorative benefits by reducing stress and evoking positive emotions (Kirillova & Lehto, 2016; Marshall et al., 2017; White et al., 2010). The aesthetic value of landscapes has been identified as an essential ecosystem service and Swaffield and McWilliam (2013) argued that there is an even stronger rationale to protect ecosystems because of the importance of this service to humans. Aesthetic appreciation of the GBR interlinks with recreational benefits and presents an important driver of visitation and possibly conservation behaviour (Kirillova, Fu, Lehto, & Cai, 2014; Le, Scott, Becken, & Connolly, 2019; Skibins, Dunstan, & Pahlow, 2017). For example, human aesthetic appreciation of natural environments has been acknowledged to increase public awareness and support for wetland conservation programs (Lee, 2017); visitors' willingness to pay for forest conservation (Biénabe & Hearne, 2006), as well as divers' willingness to pay for ocean bio-diversity conservation (Schuhmann, Casey, Horrocks, & Oxenford, 2013).

The GBR is one of the best monitored Reefs in the world. For example, the [Social and Economic Long-term Monitoring Program](#) (SELTMP), [Eye on the Reef](#) by the Great Barrier Reef Marine Park (GBRMPA), [Coral Watch](#) (led by the University of Queensland), and [Marine Monitoring Program](#) (led by GBRMPA) all monitor various aspects of the GBR (i.e., water quality, coral health, community perceptions, economic dimensions, etc.). A number of these programs provide data that could either directly or indirectly be relevant to monitoring aesthetic values, but a dedicated 'aesthetic monitoring' program is lacking. A technical report on designing an Aesthetics Long-Term Monitoring Program (ALTMP) for the GBR provided by CSIRO (Curnock, Pert, Smith, Molinaro, & Cook, 2020) provides a useful overview of existing monitoring programs that bear some relevance to monitoring aesthetic dimensions. Two previous projects ([NESP TWQ Hub Project 3.2.3](#) and [NESP TWQ Hub Project 3.2.4](#)) investigated human aesthetic assessment of the GBR, providing insights into the link between aesthetic ratings of underwater images and particular environmental attributes. The earlier research delivered the following insights or "building blocks" that are useful for this present research:
-   TWQ Hub Project 3.2.3 investigated how environmental changes influence the Reef aesthetic value. Research outcomes suggest that biodiversity, colour and water quality are three important aesthetic attributes of the GBR. The presence of colourful fish contributes the most to the Reef aesthetic, followed by colourful coral, turtle and water quality. TWQ Hub Project 3.2.4 provided similar outcomes, highlighting biodiversity and

water quality/visibility as key attributes of the GBR aesthetic value. Coral topography, fish abundance and water visibility were significantly correlated with aesthetic ratings (Marshall et al., 2019).

- In terms of research methods, project NESP TWQ Hub Project 3.2.3 tested the use of eye-tracking as a suitable tool for the objective measurement of human aesthetic assessment of GBR imagery. Eye-tracking measures (i.e., fixation duration, fixation count) reflect the audience's visual attention to different underwater GBR imagery are found as significant indicators of the audience's aesthetic assessment (Scott, Le, Becken, & Connolly, 2019; Scott, Zhang, Le, & Moyle, 2017).
- Project 3.2.4 demonstrated a link between Reef aesthetics and Reef health, and suggested pathways for incorporating indicators of Reef aesthetics into current environmental management processes (Marshall et al., 2019).

Despite considerable progress in understanding GBR aesthetics, some knowledge gaps remain. First, previous aesthetic research projects investigated how people perceive natural under-water sceneries of the GBR where human-made elements (e.g., rubbish or artificial structures) were absent. It is necessary to investigate how the presence of human elements influences aesthetic appreciation. Second, a limitation common to previous projects is the recruitment of only one Reef user group (e.g., Australian citizens) when investigating human aesthetic appreciation of GBR scenery. Exploring differences between cultural groups has not been undertaken, even though the need to understand social-cultural influences on aesthetic assessment is justified by the literature on subjective aesthetic value (see next section).

1.3 Various approaches to aesthetic value

Aesthetic value in a natural setting can be defined as:

> *"…the response (the aesthetic response) derived from the experience of an environment or parts of an environment. Human senses - sight, touch, smell, sound, movement – are important in how humans experience an environment. And culture, knowledge, expectations and past experiences mediate sensory perceptions. Aesthetic response can therefore be said to be linked to the characteristics of an environment and culturally or personally derived preferences."* (Context, 2013, p. 33)

This definition is adopted to guide our research design because it highlights that aesthetic assessment is influenced by (1) environmental characteristics and (2) cultural/personal preferences. These two dimensions of aesthetic value correspond with two traditional approaches namely objective versus subjective assessment. The current research follows an approach that considers both through a dual-perceptual model. This enables the reconciliations of objective and subjective approaches to provide a more comprehensive understanding of how human perception of natural aesthetics is formed. The two established approaches are discussed further before the dual-perceptual approach is introduced.

1.3.1 Objective aesthetic approach

Based on the Kantian idea of disinterestedness and the picturesque, aesthetic objectivists assumed that aesthetic value is inherent within natural environments (Todd, 2009). Human aesthetic appreciation results from the cognitive process of recognising the intrinsic beauty of natural environments and thus is convergent among the perceivers (Dinsdale & Fenton, 2006;

Hagman, 2002). Therefore, inherent characteristics of natural environments such as diversity, naturalness, openness, landcover, colour, water spaces, etc. are considered as reliable indicators of human aesthetic assessment (Frank, Fürst, Koschke, Witt, & Makeschin, 2013; Marshall et al., 2019; Yao et al., 2012).

The evolutionary theory constitutes the theoretical basis for an objective approach to aesthetic value. According to evolutionary theorists, aesthetic appreciation serves evolutionary adaptations for human beings, enabling the detection of suitable environments for living and survival purposes and thus providing adaptive advantages (Kaplan, 1987; Ulrich, 1993). As a cognitive process evolving along with human development history, aesthetic preference for natural environments is coded in our unconscious mind and genes (Falk & Balling, 2010). Therefore, all human beings share some residual aesthetic preferences for suitable living habitats (Ruso, Renninger, & Atzwanger, 2003; Zhang, Tang, He, & Chen, 2018).

1.3.2 Subjective aesthetic approach

The subjective approach argues that aesthetic appreciation of natural environments cannot be separated from the viewers and their cultural knowledge, learning experiences, values, emotional state and desires (Datta, Joshi, Li, & Wang, 2006; Todd, 2009). In other words, aesthetic subjectivists believe that "beauty is in the eyes of the beholder". Aesthetic assessment of natural environments functions as a socio-culturally shaped decoding operation (Bourdieu, 1986). Hence, aesthetic appreciation differs depending on the cultural meanings or interpretations attached to a natural area (Hull & Reveli, 1989).

Empirical research provides initial evidence to support the subjective approach by showing significant differences in aesthetic assessment of natural environments when the assessors have different socio-cultural characteristics. People tend to have a higher aesthetic preference for familiar landscapes (Herzog, Herbert, Kaplan, & Crooks, 2000; Strumse, 1996; Van den Berg, Vlek, & Coeterier, 1998). Cultural knowledges account for considerable variance in aesthetic assessment of natural environments among groups with different cultural backgrounds (Hull & Reveli, 1989; Yu, 1995). Other socio-cultural characteristics such as age and level of education (Howley, Donoghue, & Hynes, 2012; Strumse, 1996), living environments (Kirillova, 2015; Sevenant & Antrop, 2010), environmental attitude (Howley, 2011) are also found to influence aesthetic assessment significantly. These studies suggest that aesthetic perceptions of natural environments can be modified by individual and cultural learning experiences.

1.3.3 Dual-perceptual approach

The long and unsolved debate between the objective versus subjective approach leads to the development of a third approach, the dual-perceptual aesthetic assessment. Researchers come to an agreement that the human perception of natural aesthetics is neither wholly subjective, nor wholly objective (Forsey, 2016). In fact, aesthetic assessment results from the interaction of these two perceptual layers: (1) an objective layer based on cognitive recognition of inherent characteristics of natural environments and (2) a subjective layer based on decoding/interpreting socio-cultural meanings associated with these places (Brady, 2016; Graf & Landwehr, 2017). These two aesthetic assessment layers are processed by two underlying brain mechanisms: (1) the objective aesthetic assessment layer may be at the scale of evolution, which is more universal among humans and (2) the subjective aesthetic assessment

layer may be at the scale of reinforced learning within socio-cultural contexts, which becomes more flexible and individualised (Aleem, Pombo, Correa-Herran, & Grzywacz, 2019). Figure 2 presents how two perceptual layers could contribute to an overall aesthetic assessment of natural environments.
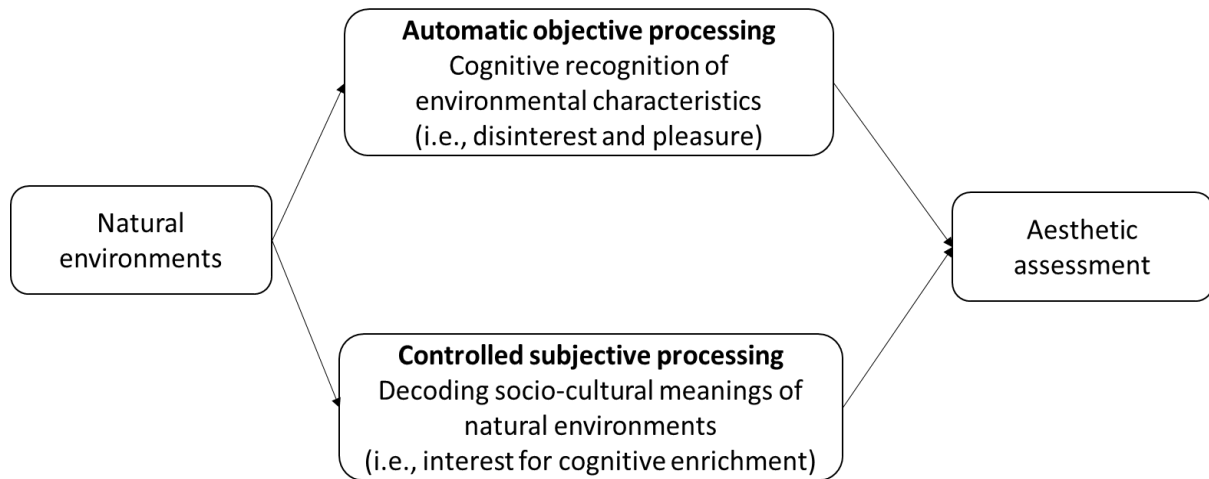
Figure 2: Two perceptual layers contributing to aesthetic assessment

This dual-perceptual model is beneficial in understanding how Reef user groups with different socio-cultural backgrounds perceive the aesthetic value of the GBR. As environmental characteristics (e.g., colour, water quality) can be objectively shared among viewers, cognitive recognition of environmental characteristics forms the objective aesthetic evaluations of natural sites. The subjective layer refers to culturally or personally derived preferences that are built based on one's socio-cultural knowledge, meanings and experiences related to specific natural environments. This subjective layer has not been specifically addressed in previous research of the GBR aesthetics and will be investigated in the current research.

2.0 RESEARCH OBJECTIVES, SCOPE AND METHODOLOGY

2.1 Research objectives and scope

The current research focuses on exploring how three Reef user groups (First Peoples, non-Indigenous Australian citizens and Chinese visitors) with different social-cultural backgrounds perceive the aesthetic value of the GBR. In order to achieve this overall aim, five specific research objectives are established as follows:

1   Verify potential social-cultural differences and experiences among three Reef user groups that potentially influence aesthetic assessment. The differences are examined based on an exploratory qualitative study (i.e., focus group discussion) and statistically testing of self-report data (see sections 3.1.1, 3.2.1 and 4.1).

2   Establish whether aesthetic assessment is formed based on two perceptual layers (objective recognition of environmental characteristics and subjective interpretation of socio-cultural meanings) (see sections 3.1.2 and 4.2).

3   Explore the relative contributions of the objective and the subjective layer to the overall aesthetic assessment of the GBR. In particular we are interested in whether the subjective layer causes considerable variances in the aesthetic assessment (see sections 3.2.2 and 4.2).

4   Assess how different groups perceive the existence of human-made elements (i.e., rubbish and coral restoration structures) and how these influence individuals' aesthetic assessment (see sections 3.1.2, 3.2.2 and 4.3).

5   Test the usefulness of advanced research technologies (i.e., eye-tracking, face-reader) in investigating aesthetic assessment and the necessity of using two self-report aesthetic measurement scales (i.e., beauty versus pleasantness) (see sections 3.2.3 and 4.4).

2.2 Methodology

2.2.1 Study 1: Focus groups

In the first phase of data collection, 29 respondents were recruited in four focus groups (see Appendix 1 for a detailed profile of participants):

1)   Focus group with 7 non-Indigenous Australian citizen respondents: 2nd May 2019
2)   Focus group with 8 Chinese visitor respondents: 7th May 2019
3)   1st focus group with 5 First Peoples respondents: 31st May 2019
4)   2nd focus group with 9 First Peoples respondents: 5th June 2019

During each focus group, respondents were asked to share their top-of-mind and personal experiences with the GBR. Next, they worked together to rank 20 underwater images of the GBR from what they thought to be the most beautiful, to the least beautiful scenery in two rounds (10 images/round). These 20 images represent five environmental conditions of the GBR (highly aesthetic, medium aesthetic, low aesthetic, polluted areas with the presence of some rubbish and coral restoration sites). These were selected based on aesthetic ratings in project NESP TWQ 3.2.3 and an agreement among the research team of eight experts. These same images were also used in the follow-up quantitative study (see Appendix 3).

Respondents were encouraged to discuss their assessment with fellow group members to reach a group agreement on the aesthetic ranking of the GBR images. Individual rankings are not of interest because this study aims to explore group differences.

With the approval of all participants, each focus group was audio-recorded and later transcribed using REV Ltd.'s transcribing services. The length of each focus group was about one hour, and 102 pages of textual transcription were generated across the four group discussions. Leximancer software version 4 was used to perform thematic and content analysis of the transcription from each Reef user group (First Peoples, non-Indigenous Australian citizens and Chinese visitors). In contrast to a human coding process, Leximancer transforms textual documents into semantic patterns in an unsupervised manner that helps to reduce preconception bias found within a manual analysis process (Schweinsberg, Darcy, & Cheng, 2017).

Leximancer automatically identifies key concepts frequently mentioned within participants' conversation and generates meanings (i.e. themes) by creating visual concept maps (Scott et al., 2017). Several steps must be followed to achieve interpretable results: (1) meaningless words such as "during" or "able", "the" have to be removed; (2) similar concepts are merged together as a concept (e.g., "image" and "picture"); (3) a series of repeated functions are undertaken to explore and modify the main concepts within the text; (4) key concepts are mapped into themes based on the relationships between them (Tseng, Wu, Morrison, Zhang, & Chen, 2015).

The outputs of data analysis using Leximancer are concept maps, visualising the key themes and concepts from the discussions within each Reef user group. The relative importance of a theme is indicated by its colour and the number of concept occurrences (i.e., the number of text blocks in participants' interviews associated with the theme) (Leximancer, 2018). Hot colours such as red or orange denote more important themes while cool colours such as blue and green denote those less important (Schweinsberg et al., 2017).

2.2.2 Study 2: Innovative technologies and survey questions

A follow-up quantitative study was conducted to statistically verify socio-cultural influences on aesthetic assessment among the three groups that became apparent during focus group discussions. In this data collection phase, we drew on a large sample (i.e., 93 participants), using both self-report and advanced research technologies including Tobii T60 eye-tracker technology and FaceReader™ software based on the Ekman and Friesen' Facial Action Coding System (FACS) to measure participants' responses. Figure 3 shows the lab setting for this experiment.

Figure 3: The eye-tracking & face-reader lab setting

Advanced technologies were used in combination with self-reporting measurements for a better understanding of socio-cultural differences and socio-cultural influences on aesthetic assessment among three groups. Eye-tracking provides a measure of visual attention, enabling researchers to explore further potential differences among three groups regarding their interest in viewing and assessing the GBR aesthetics. Previous research (NESP 3.2.3) demonstrated that eye-tracking measures of viewers' visual attention (i.e., fixation duration and fixation count) and aesthetic ratings are correlated, suggesting the usefulness of eye-tracking in aesthetic research. This study verifies the usefulness of eye-tracking in aesthetic research in a cross-cultural context. Participants were exposed to 20 images of underwater GBR scenery in random order which were used in the previous focus groups (see Appendix 3). Figure 4 shows an example of how an eye-tracking heatmap was generated and eye-tracking data was recorded.

Image provided (Beauty1)   Eye-tracking record & analysis   Heatmap generated
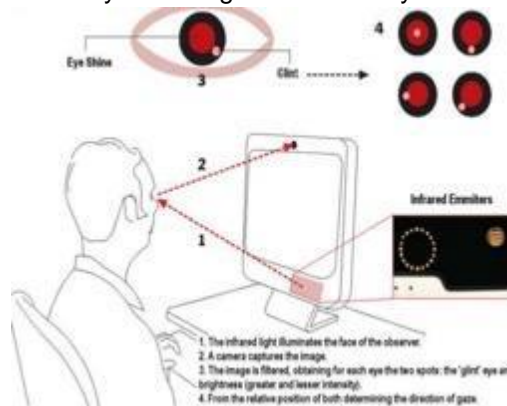
Figure 4: An example of how eye-tracking heatmaps are generated based on participants' visual attention

Face-reader measures provide insights into viewers' simultaneous emotions in response to the GBR tourism promotion video. Figure 5 visualises how face-reader technology is employed to measure participants' emotional responses.

Figure 5: Example of how FaceReader™ screen records and analyses viewers' emotional responses

Data were collected in July and August 2019. In total, 98 participants were recruited at the Gold Coast and Nathan campuses of Griffith University, but 5 participants were excluded from the sample due to faulty data recorded in the eye-tracking software. Among them, 35 First Peoples participants were selected thanks to the support of GUMURRII, a dedicated support unit for Aboriginal and Torres Strait Islander students at Griffith University. The profiles of participants are presented in Table 1. The large number of young participants is explained by the recruitment of Griffith students in campus. Given that age could be an influencing factor of aesthetic assessment (Le, Scott, Becken, et al., 2019), the use of a dominantly young sample will reduce potential bias in this study.

Table 1: Profiles of the participants in the eye-tracking and face-reader experiment

Demographics		Number	Percentage
Age	18-24	59	63.4
	25-34	20	21.5
	35-44	7	7.5
	Over 45	7	7.5
Gender	Male	44	47.3
	Female	59	52.7
Group	Chinese	30	32.3
	Australian	31	33.3
	First Peoples	32	33.4

Eye-tracking and face-reader experiments were designed to include several sections as follows (see Figure 6): (1) demographic questions, (2) an aesthetic assessment of 16 general under-water GBR images, (3) measurements of emotional responses to two GBR videos (tourism promotion and coral restoration), (4) an aesthetic assessment of four coral restoration pictures, and (5) post-experiment interviews. After providing consent to participate in the eye-tracking experiment, the respondents went through a calibration process. Participants were qualified and recruited based on a lack of any eye problems or facial recognition issues. After

completing the questionnaire on the eye-tracking screen (see Appendix 2 for the full questionnaire).

Demographic questions

- Age
- Gender
- Group classification
- GBR knowledge
- GBR visit experiences
- Diving/snorkelling experiences

Aesthetic assessment

20 pictures used in the focus group, representing five environmental conditions of the GBR
2 questions/picture:
- Aesthetic judgment (beauty)
- Aesthetic emotion (pleasantness)

GBR tourism promotion video

Self-report of emotions (valence and arousal)
Facial reader to measure participants' emotions based on facial expressions
Attitude toward the GBR as a tourism destination

Figure 6: Sections included in the eye-tracking experiments

Aesthetic assessment is measured by two self-report questions: aesthetic (cognitive) judgement (i.e., beauty) and aesthetic emotion (i.e., pleasantness) (Leder, Belke, Oeberst, & Augustin, 2004; Leder & Nadal, 2014). Aesthetic appreciation of natural scenery is intimately connected with pleasant emotions of experiencing them (Forsey, 2016). Whilst Curnock et al. (2020) propose one measurement scale (i.e., ugly to beautiful), we include two self-reporting measurement scales for aesthetic assessment (i.e., beauty and pleasantness). The purpose was to test the necessity of using two scales to measure aesthetic assessment.

The eye-tracking, face-reader, and self-report data were exported to Excel files and imported into IBM SPSS version 24 where further statistical analysis was conducted. The Tobii eye-tracker recorded the direction of the respondent's attention some 60 times per second and mapped this onto a location on the image being viewed, creating heatmaps (see Appendix 3). Subsequently, these mapped points were analysed to determine a fixation count and fixation duration of each participant on each picture based on the criteria of 250ms for a fixation (i.e., eye gaze). Additionally, the mean scores of FaceReader™ facial emotional records were recorded and analysed.

3.0 RESULTS

The results are presented in this section in order of data collection. In Section 3.1, Study 1 findings are introduced to verify social-cultural differences among three Reef user groups (research objective 1) and the involvement of two perceptual layers in aesthetic assessment (objective 2). In Section 3.2, Study 2 findings are provided to statistically confirm social-cultural differences among three groups (objective 1) and demonstrate the relative contributions of two perceptual layers to overall aesthetic assessment (objective 3). Also, section 3.2. contains further analyses of the influences of human-made elements (objective 4) and results of testing various research methodologies in aesthetic research (objective 5).

3.1 Study 1 Findings

An overview of Study 1 findings is introduced in Table 2, including three concept maps created by Leximancer for the three Reef user groups in correspondence with the main themes/ topics of each of the focus group discussions. These concept maps are derived from the transcripts of the focus groups. The key topic of discussion in all focus groups remains participants' aesthetic assessment of the GBR underwater scenery (i.e., perceived beauty). A comparison of three concept maps shows noticeably different discussion themes among the three user groups, which are related to their considerable differences in socio-cultural connotations, knowledge and meanings related to the GBR. These differences are further analysed in section 3.1.1. Section 3.1.2 provides details of key aesthetic attributes of the underwater GBR that explain groups' aesthetic ranking of underwater environments.

Table 2: Thematic analysis of the transcribed discussions from the three focus groups

Chinese visitors
Perceived beauty: 183 concept occurrences
Tourism experience: 93 concept occurrences
GBR image: 26 concept occurrences
Safety: 9 concept occurrences
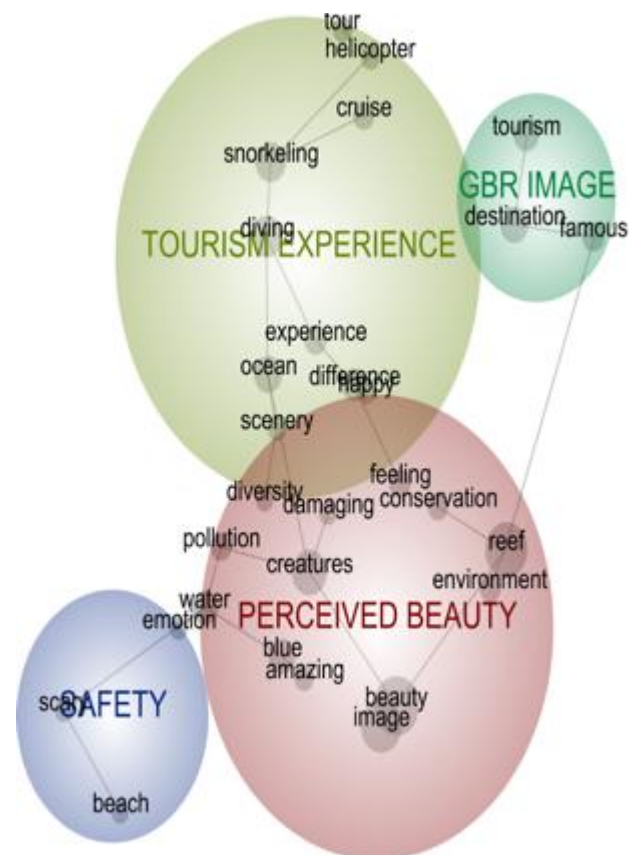
Non-Indigenous Australian citizens
Perceived beauty: 228 concept occurrences
Tourist experience: 105 concept occurrences
Reef changes: 35 concept occurrences
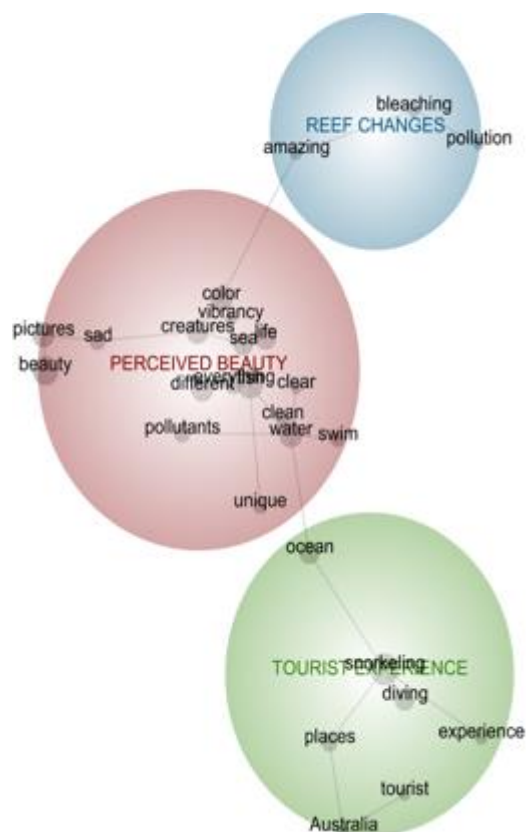
First Peoples
Perceived beauty: 227 concept occurrences
Reef changes: 189 concept occurrences
Tourism: 73 concept occurrences
Stewardship (Indigenous attachment): 50 concept occurrences
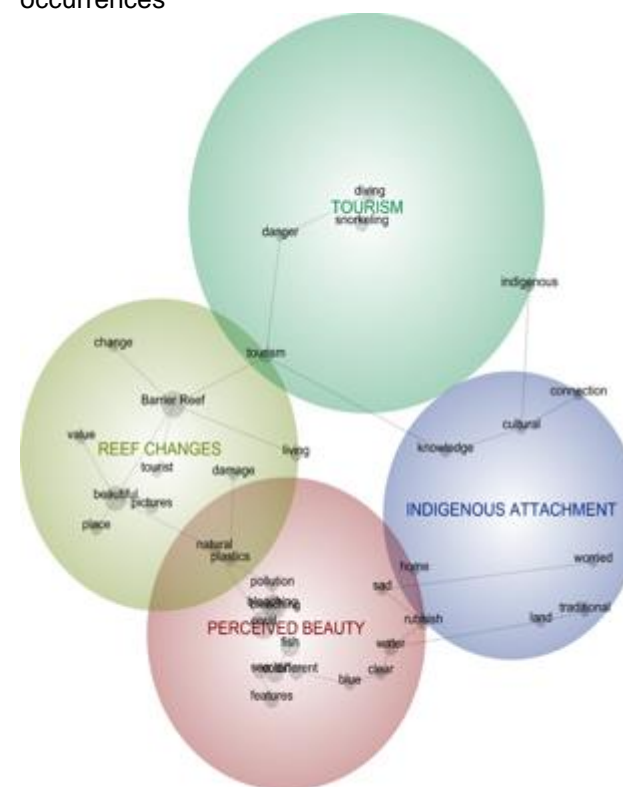
3.1.1 Socio-cultural differences among three groups

This exploratory qualitative study provided initial evidence of socio-cultural differences among three groups when they were asked what came to their mind when they thought about the GBR. This question was important to establish a baseline of how the three groups might 'frame' the Reef, as this could shape the way they look at it from an aesthetic point of view. As can be seen from three concept maps in Table 2, Chinese visitors and non-Indigenous Australian citizens appeared to appreciate GBR aesthetics through the eyes of (potential) visitors and mainly focused on their previous visit experiences. In contrast, the focus group discussions with the First Peoples participants centred around their concerns of how to involve the local GBR Indigenous communities (i.e., the "host destination communities") in environmental management and tourism development (Tourism: 73 concept occurrences). More importantly, First Peoples demonstrated their connection to country and/or the GBR by sharing the cultural meanings of the Reef (Indigenous attachment: 50 concept occurrences).

Chinese visitors and non-Indigenous Australian citizen participants represented two (potential) visitor groups, who appreciated the GBR aesthetics from two angles: a dominant aerial view for Chinese visitor participants versus a dominant underwater and ocean view for non-Indigenous Australian citizen participants. Non-Indigenous Australian citizen participants were more familiar with beaches/ oceans and expressed greater interest in water-related experiences. For example, participant 1 noted (male, 18-25 years old, non-Indigenous Australian citizen): *"(What first comes to my mind when thinking about the GBR is) the tourism aspect of it, swimming around, so I guess swimming, snorkelling, diving, or boating, kind of the same thing*".

In contrast, the fear of getting involved in water-related activities was common among Chinese visitor participants, as participant 13 (female, 18-25 years old, Chinese) pointed out: "*I only took the boat, the boat with glass bottom windows to see the GBR. But the other people they do snorkelling or diving…. because I'm scared of water. I don't have confidence. Also, there are lots of jelly fish. So, I'm so scared*". Therefore, Chinese visitors looked for a sense of safety (9 concept occurrences) when participating in tourism activities, and this was a key influencing factor in their aesthetic assessment. If tour companies are unable to comply with safety standards, Chinese visitors may be less satisfied with their aesthetic experiences. For example, participant 14 (male, 18-25 years old, Chinese) recalled: *"I only did that once (snorkelling) in Thailand. And I will rate it zero because it's too unprofessional, the agent, and they are not responsible for our safety".*

Chinese visitors appeared more interested in taking helicopter tours to appreciate the GBR aesthetics from the air. According to Chinese visitor participants, the aerial view was exceptional and their aesthetic experience of the GBR from the sky were often extremely satisfying. One of *(Participant 11, female, 18-25 years old, Chinese)* said:

> *"I did not go snorkelling cause I have the boat sick… It was just fabulous, because I saw the videos before and I was like, "Uhh, I don't think it will be looking exactly the same as the videos." When I was there, I was like, "Oh, wow! This is much more beautiful than the videos." Yeah, it was really fantastic!"*

Compared to the two other groups, First Peoples participants discussed human activities in the Reef regions from a different perspective. It is recognised that First Peoples have a "*profound spiritual connection to land. Aboriginal law and spirituality are intertwined with the land, the people and creation, and this forms their culture and sovereignty*" (Spirits, 2020, p. 1). Thus, First Peoples participants were more concerned about the fragility of the GBR in the context of global warming and the impact of over-exploitation. Hence, they highlighted the importance of enhancing "responsible tourism" and "culturally appropriate tourism".

Responsible tourism means eco-friendly, well-organised, educational/cultural tours that limit the impact of tourism on the Reef ecosystem. According to Participant 21, (male, 25-35 years old, First Peoples), if tour operators profit from the Reef, they should give back by involving visitors in conservation efforts, educating visitors so they undertake responsible behaviour and "*spreading tourism, spreading tourists to various regions... so that the Reef can recover*". Currently, GBR tourism growth has been concentrated in cities, such as Cairns or Airlie Beach, and creates pressure on these destinations' carrying capacity, including the Reef environment. The necessity of enhancing responsible tourism is clearly illustrated in the following *(Participant 25, male, 35-45 years old, First Peoples)*:

> *"As opposed to them (big visitor groups) doing a different kind of tour where you're a very small group of very limited numbers where there's much less likelihood of impact? There's got to be an education piece with the tourism…if the tourism operators could educate all the tourists on plastics and the damage that they cause to Reefs in their own countries? By not having plastics on board their boats. Banning that, … I mean banning single-use plastic bottles. Having refillable stations and really encouraging that"*

Indeed, First Peoples participants also raised the necessity of designing and running culturally appropriate tours in collaboration with local Indigenous communities in the Reef regions. Participant 28, (female, 18-25 years old, First Peoples) explained that when Indigenous people travel to the country of another tribe, they need to establish a "*rite of passage*" by respecting and learning the traditional practices of that particular Indigenous community. A rite of passage is essential to show that "*we respect that this is your country and you've been here for a very long time, and we don't want to cause any rift between the two of us. So, we're going to meet you halfway and see what we are allowed to do and what we can't do*".

Arguably, demonstrating respect for Indigenous culture, traditions, and knowledges will facilitate a more sustainable approach to tourism in the GBR than is currently being adopted, where activities have a tendency to focus on harnessing the GBR natural aesthetics but overlooking the rich cultural aspects. Indeed, First Peoples participants suggested that by promoting the cultural significance of the GBR and integrating Indigenous cultural narratives into tours, future long-term tourism development in the Reef regions will be culturally authentic, appropriate and far more sustainable:

> *"Tourists can understand, read, have knowledge of and take a cultural lesson away but without destroying the footprint of the place. I just unfortunately see it as just such a tourism wheel, and I would rather see that tourism wheel became the story and the knowledge and the significance of the place and so I think that the tourism wheel is currently upside down. And it's flipped the*

> *wrong way and it needs to be flipped back. And then perhaps if that, with the new narrative ... The new narrative of the Great Barrier Reef needs to be about its cultural significance, it needs to be about its World Heritage status".*
> *(Participant 19, male, 25-35 years old, First Peoples)*

In brief, content analysis of focus group discussions provided evidence that confirms socio-cultural differences among three selected groups. Figure 7 visualises overlapping and different elements in socio-cultural knowledge and experiences with the GBR among three groups. These socio-cultural differences potentially influence aesthetic perception of GBR underwater environments among the three groups (analysed further in the next section).
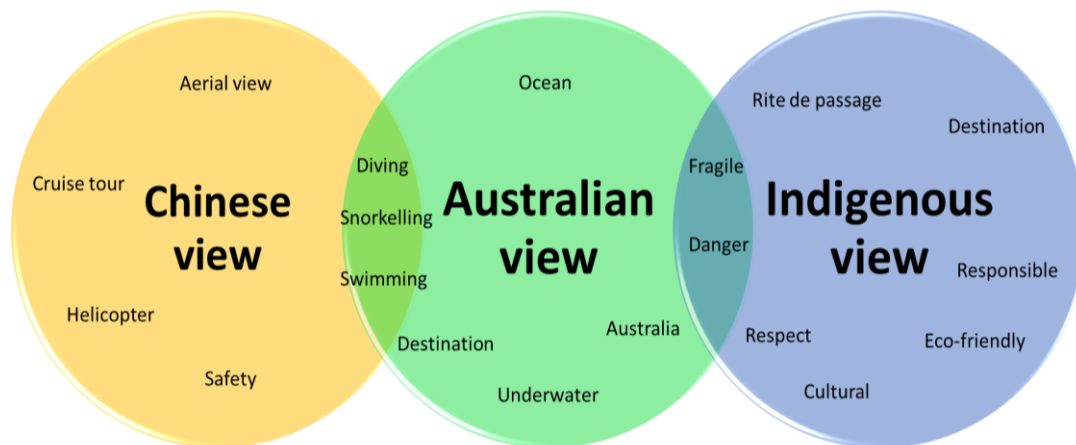
Figure 7: Differences in socio-cultural knowledge and experiences with the GBR among three groups

3.1.2 Evidence of objective and subjective layers in aesthetic assessment

The Reef's key aesthetic attributes were well discussed by all three groups: Chinese visitor participants (183 concept occurrences), non-Indigenous Australian citizens (228 concept occurrences) and First Peoples (227 concept occurrences). By comparing key concepts related to aesthetic assessment (i.e. perceived beauty) among three groups (Table 2), it can be seen that similar aesthetic attributes emerged (i.e., blue/clear water, coral reef health, sea life, colour, weather, naturalness versus pollution). Further content analysis of these attributes was conducted to establish a list of environmental characteristics that form the objective layer of aesthetic assessment.

Some differences in aesthetic assessments among three groups, were noticeable. Table 3 shows how three groups rank ten images of five different environmental conditions in two rounds (10 pictures each). In round 1, the Human 3 picture, which shows a turtle eating a plastic bag in the clear blue ocean, was ranked as a medium aesthetic scene by Chinese visitor participants but rated among the lowest aesthetic scene by non-Indigenous Australian citizens and First Peoples participants. In round 2, First Peoples ranked coral restoration images higher than the other two groups. Socio-cultural factors, that potentially influence aesthetic assessment, were also analysed to better understand the objective layer of aesthetic assessment.

Table 3: Differences in aesthetic ranking among three groups

Chinese participants	Non-Indigenous Australian participants	First Peoples participants
Round 1		
Round 2		

Objective layer based on well-agreed environmental attributes

All three groups shared six similar environmental attributes that they discussed to explain their aesthetic rankings: (1) Water quality/clarity, (2) diversity of sea life (i.e., fish, turtle and other aquatic species), (3) coral richness and coral health, (4) colour vibrancy; (5) weather, and (6) naturalness. These attributes are consistent with previous research on GBR aesthetics (Johnston & Smith, 2014; Le, Scott, & Lohmann, 2019; Marshall et al., 2019).

In terms of water quality/clarity participants followed the same principle: the clearer the water, the higher its aesthetic value. Poor water quality (i.e., murky, unclear, polluted, etc.) led to negative aesthetic rankings. Further, blue and clear sea makes the GBR more aesthetically appealing. This point was made clear in a discussion with participant 6 (male, 18-25 years old, non-Indigenous Australian citizen) who suggested that:

> *The water is really like "whoa" when I went. The water was really, really clear and you could see everything and the depth as well because sometimes you have to dive a little bit to see things… I mean some of the areas that I have been, because I've been in Mexico and that was a little bit like cloudy…not as clear as the GBR.*

Second, all groups shared their aesthetic preferences for GBR scenery with abundance and diversity of marine species. Many participants claimed that *"(What makes the GBR beautiful) It's just the amount of sea life that's in there. There's so many different forms, and micro-organisms, and stuff like that as well… It's also just a big lump of life"* (participant 2, 18-25 years, female, non-Indigenous Australian citizen). Additionally, visitors highly appreciated the exceptional beauty of the GBR due to the presence of diverse species and their enjoyment of animal encounters. For example, participant 9 (female, 18-25 years old, Chinese) said "*I did snorkelling in other regions, like Malaysia or Thailand. Their Reefs were good as well, but I think the GBR is more beautiful…because you have lots of fish around you, you will feel that it is wonderful*".

Third, all three Reef user groups considered the quantity of rich, healthy, and colourful coral as a unique aesthetic attribute of the GBR. For example, a Chinese visitor participant emphasised this special characteristic of the GBR by noting "we don't have the GBR in China or anywhere else in the world" (Participant 10, 18-25 years, male, Chinese). The GBR scenery would lose its aesthetic appeal if coral was degraded due to bleaching or other impacts, as illustrated in the following discussion:

> *"With the bleaching and the coral dying, all of these animals are going to depart soon. Then you won't be able to see all these different creatures like you do, down there. So that would be weird... There's less animals and everything. That would be very less appealing" (Participant 4, female, 18-25 years old, non-Indigenous Australian citizen).*

Fourth, vibrant colours are an important indicator of GBR aesthetics. On the one hand, the blue colour of seawater indicates a high level of water quality/ clarity in the Reef regions (see above). On the other hand, a variety in colours was found to increase human aesthetic assessment of the GBR scenery (confirming earlier results by Le et al., 2019). For example,

colourful fish are more aesthetically pleasing than non-colourful fish (Tribot et al., 2018). Indeed, Reef users relied on coral colour to evaluate coral health: colourful coral signals a healthy and growing Reef but fading colours such as white or grey are perceived to indicate potential bleaching, damaged, or dead coral (even though this may not always reflect ecological conditions). Participant 5 (female, 18-25 years old, non-Indigenous   Australian citizen) expressed such knowledge by saying "*(I know it is not healthy) just when they turn white and grey. That's when they're losing their colour and everything due to all the different issues that make it not as healthy*".

Fifth, weather is important. The GBR achieves its highest aesthetic value in good weather conditions. In contrast, inclement weather conditions such as heavy rain or strong wind reduce human aesthetic appreciation of the GBR. For example, participant 12 (female, 18-25 years old, Chinese visitor) explained:

> *"When I went there, it had just stopped raining… it was lots of heavy raining…I didn't see a beautiful view... So the water was grey, it was not blue at all. And we took the boat, the boat with the glass at the bottom… but it was harder to see anything".*

Finally, participants assessed the GBR aesthetics based on naturalness. From the focus group discussions, it appears that beautiful Reef scenery must look pristine and untouched. The presence of human pollutants such as plastic bags, rubbish, etc. negatively impacted participants' aesthetic appreciation of the GBR scenery. For instance, one First Peoples participant compared the well-protected GBR with other polluted Reef areas and concluded:

> *"I've done a lot of snorkelling around, been wanting to around Southeast Asia and stuff, and there's absolutely no way that actually compares…(because) the pollution levels are quite high… Yeah, I mean the rubbish. The sceneries with the pollution and just seeing the greyed out corals and everything. That doesn't make it as pretty or beautiful" (Participant 20, female, 35-45 years old, First Peoples).*

Subjective layer based on specific socio-cultural meanings

The subjective layer of the GBR aesthetics is related to individuals' emotions, knowledge, and experiences with the GBR (Bourassa, 1990). All three groups agreed on the most beautiful images of the GBR that met the six environmental attributes discussed in the previous section. However, there were some notable differences in the assessment of the less aesthetically appealing images (see Table 3). These are potentially related to how each group attaches special socio-cultural meanings to the GBR. First of all, non-Indigenous Australian citizens and First Peoples were more concerned about Reef changes (Table 2). They expressed higher levels of negative emotions (i.e., sadness, worry, anxiety) toward the presence of any human "footprint" in the images and ranked these the least aesthetically appealing. Participant 5 (female, 18-25 years old, non-Indigenous Australian citizen) noted:

> *"The fact that it's a plastic bag, which we have obviously put there, all of these things this natural erosion and stuff, but that plastic bag, that wasn't anybody else's fault but ours. It is so heart-breaking; they're killing our animals".*

Chinese visitor participants who were perhaps familiar with high levels of air and water pollution in their home country, seek clean and clear environments when visiting Australia. For example, Chinese visitor participants showed a higher aesthetic preference for blue-water images. Also, they gave lower aesthetic rankings to murky-water images which may have been seen as a sign of seriously polluted areas. This is clarified by a Chinese visitor participant who said *"In China, we do not have that pure or clean part of the ocean. I'd rather swim in this place (i.e. blue ocean with the turtle and a plastic bag), but not this murky water because it looks dirty"* (Participant 8, female, 18-25 years old, Chinese visitor).

Due to their concerns about environmental changes in the Reef regions, non-Indigenous Australian citizens and First Peoples participants experienced positive emotions of hope in response to coral restoration sites. Hence, they tended to appreciate the aesthetics of coral restoration sites compared to Chinese participants. For example, participant 7 (female, 18-25 years old, non-Indigenous Australian citizen) said: "*I appreciate the effort in both of these (coral restoration) pictures… Although this does look man-made, that just looks like someone made a Christmas tree out of coral… so I know once grows out, hopefully, it will look better".*

As the analysis of socio-cultural context has shown, Chinese put great emphasis on safety. Concerns about safety and resulting negative emotions have an impact on how Chinese perceive the beauty of the Reef, hence there appears to be a link between feelings of fear (or ease in the opposite case) and beauty assessment. Participant 15 (female, 18-25 years old, Chinese) discussed the importance of safety measures when considering GBR aesthetics: *"When it makes you feel safe, you have more time to focus on the beauty of the water. But when you feel dangerous, you're just like, I want to go back to the boat, right?... when you don't feel safe, you cannot focus on the surrounding".*

First Peoples demonstrated a cultural and spiritual connection with country and discussed two additional aesthetic attributes of the Reef that were not discussed by non-Indigenous Australian and Chinese visitor participants suggesting the magnitude and the cultural significance and meaning of the GBR. First Peoples were cognisant of the magnitude of the Reef when evaluating its exceptional beauty. For example, participant 16, (female, 25-35 years old, First Peoples) emphasised that *"(What makes the GBR beautiful is…) the size. It's the biggest in the world. You don't get this anywhere else in the world. We're very lucky to have it here on our doorstep because of the size of it. I think you can see it from space, can't you?"*

Furthermore, First Peoples highlighted the cultural significance of the GBR as an important attribute of their aesthetic assessment. In Indigenous culture, the GBR is the birthplace from "*where all different kinds of fish came from*" and is attached to special cultural meanings. More specifically, First Peoples participants and in particular, those who identified as Torres Strait Islanders, shared various dreamtime stories that related to the GBR to explain how aquatic species of the Reef such as stingrays, sharks, and dolphins evolved from their ancestors. Therefore, they suggested that the GBR could and arguably should be, aesthetically appreciated through a cultural lens. In their opinion, it is important that visitors to the Reef are taught about traditional narratives and perspectives in order to fully understand the cultural and spiritual significance and cultural aesthetics of the GBR. One of First Peoples participants (participant 19, male, 25-35 years old, First Peoples) argued *"(The Reef) it doesn't have as much value or as much beauty if it doesn't have the cultural significance. Cultural significance is important and…that could be something that could be looked at".*

In summary, content analysis of focus group discussions demonstrated the involvement of objective and subjective layers in aesthetic assessment among three groups (Figure 8). Six environmental characteristics were shared among three groups as the basis of the objective layer of aesthetic assessment of underwater GBR environments. Additionally, socio-cultural attributes (e.g., cultural significance, narratives, and emotions) were linked to the subjective layer and cause variations in aesthetic rankings among the three groups.
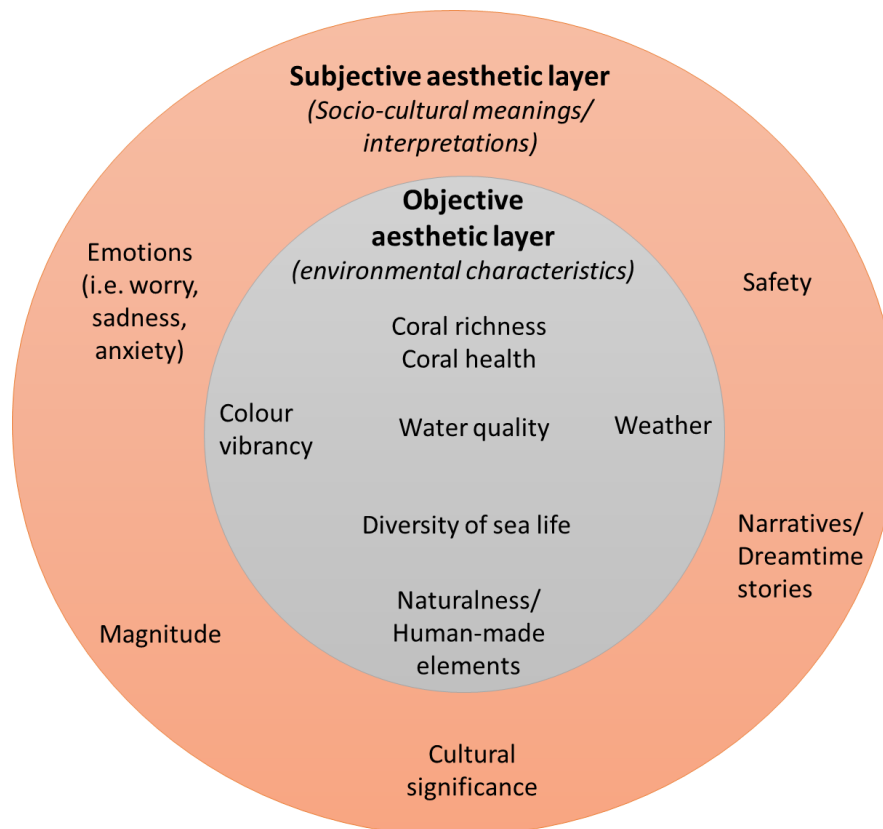
Figure 8: Key aesthetic attributes of the underwater GBR environments classified into objective layer versus subjective layer

3.2 Study 2 Findings

Study 1 provides initial evidence to support the dual-perceptual model. Both environmental attributes and socio-cultural meanings were found to explain the similarities and differences in aesthetic assessment among three Reef user groups. In order to verify the outcomes of Study 1, a sample of three Reef user groups (93 participants) was employed in Study 2. Statistical results offer additional insights into the underpinning socio-cultural differences among three groups (research objective 1), the existence (objective 2) and relative contributions of objective versus subjective layers to overall aesthetic assessment (objective 3). Study 2 findings also suggest how the presence of human-made elements (coral restoration and rubbish) influences aesthetic assessment (objective 4). Finally, the validity of different research methods (eye-tracking, face-reader, self-reports) was tested to make recommendations for future aesthetic research (objective 5).

3.2.1 Confirmation of socio-cultural differences among the three groups

The quantitative study provides further evidence that the three groups displayed significant differences in their socio-cultural knowledge, experiences, emotions, and attitudes toward the GBR as a tourism destination (Table 4). Understanding these differences is necessary for uncovering and interpreting differences in the subjective aesthetic assessments provided by members of the three groups.

Table 4: Socio-cultural differences among the three groups

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
GBR_EX* Have you been to the GBR?	Between Groups	18.543	2	9.272	11.635	.000
	Within Groups	71.715	90	.797		
	Total	90.258	92			
DIVING_EX* Have you involved in any diving/ snorkelling experiences?	Between Groups	26.891	2	13.446	12.663	.000
	Within Groups	95.560	90	1.062		
	Total	122.452	92			
GBR_KNOW* How much do you know about the GBR?	Between Groups	7.958	2	3.979	9.345	.000
	Within Groups	38.322	90	.426		
	Total	46.280	92			
GBRV_Valence* Please indicate how you felt while watching the GBR promotion video (sad/happy)	Between Groups	6.444	2	3.222	5.171	.007
	Within Groups	56.073	90	.623		
	Total	62.516	92			
GBRV_Arousal Please provide an indication of how much you felt excitement, joy, wonder, amazement, or surprise while watching the GBR promotion video	Between Groups	2.347	2	1.173	1.686	.191
	Within Groups	62.643	90	.696		
	Total	64.989	92			
GBR_AFTER* How is your overall attitude towards the Great Barrier Reef as a tourism destination?	Between Groups	10.260	2	5.130	6.238	.003
	Within Groups	74.019	90	.822		
	Total	84.280	92			

Significant at $p<0.01$

First Peoples participants demonstrated the highest levels of self-assessed knowledge about the GBR (median of 2.75), followed by non-Indigenous Australian citizens (median of 2.38). Compared to these two groups, Chinese visitor participants had relatively limited GBR knowledge (see Figure 9). It is worth noting that despite their low level of knowledge about the GBR (median of 2.03 on a 5-point Likert scale), most Chinese visitor participants (80%) were

aware that the GBR is a famous tourist destination in Australia, known for its exceptional natural beauty.
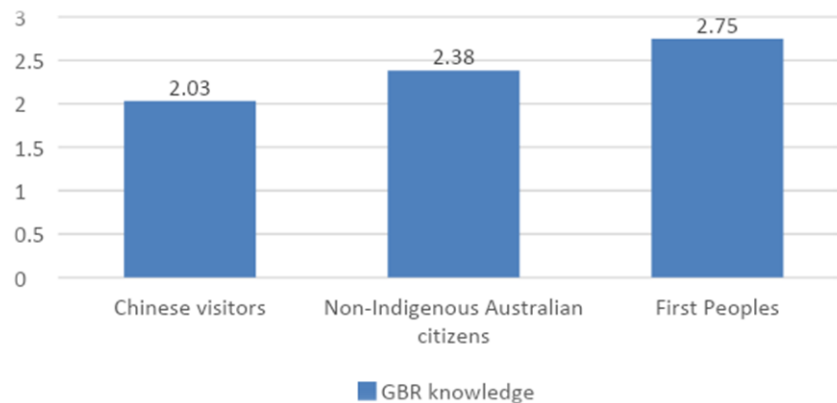
Figure 9: Self-assessed knowledge about the GBR among the three groups

Only 33.3% of Chinese visitor participants had visited the GBR, compared to 51.6% of non-Indigenous Australian citizens and 65.6% of First Peoples participants. Chinese visitor participants had on average the lowest level of GBR visiting experiences on a 4-point scale from 1_never to 4_over 3 times (see Figure 10).
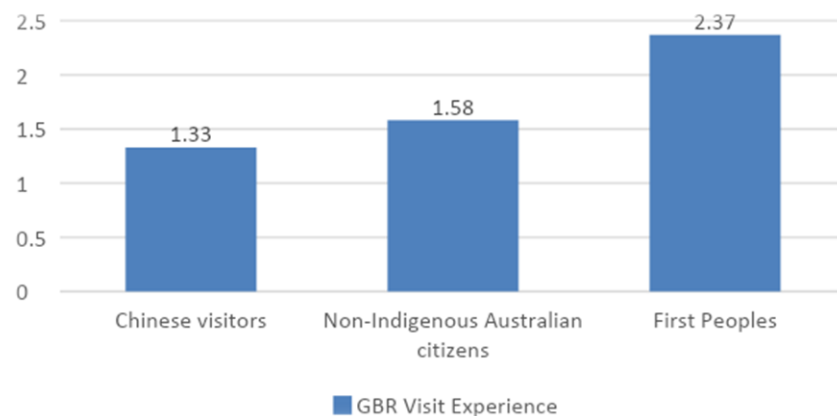
Figure 10: GBR Visiting experiences among the three groups

Research outcomes confirm the finding of the previous qualitative study that Chinese visitors are unfamiliar with water-related activities (see Figure 11). Only 30% of Chinese visitor participants had some water-related tourism experiences such as diving or snorkelling. Meanwhile, 67.7% of non-Indigenous Australian citizens and 75% of First Peoples participants had been involved in these experiences. About one-third of the First Peoples sample identified as Torres Strait Islanders and were very familiar with the GBR and its rich diving/snorkelling experiences.

Figure 11: Water-related experiences within the GBR among the three groups

After viewing a promotional video of GBR tourism, participants were asked to disclose their emotions and attitudes towards the GBR as a tourism destination. The level of emotional arousal (i.e., the intensity of emotions) evoked by the video did not significantly vary among three groups but emotional valence (negative versus positive) did. Specifically, Chinese visitor participants experienced the highest levels of positive emotions in response to the GBR tourism promotion, followed by non-Indigenous Australian citizens, and lastly First Peoples participants (see Figure 12). Statistical testing confirms the findings from the focus groups: Chinese visitors and non-Indigenous Australian citizens viewed the GBR promotion video from a visitor perspective and experienced more positive emotions when anticipating their future visit to the GBR. In contrast, First Peoples appeared to watch the GBR promotion video from the perspective of stewardship of country as they experienced less-positive emotions, arguably due to concerns about the impact of tourism on the Reef ecosystem.
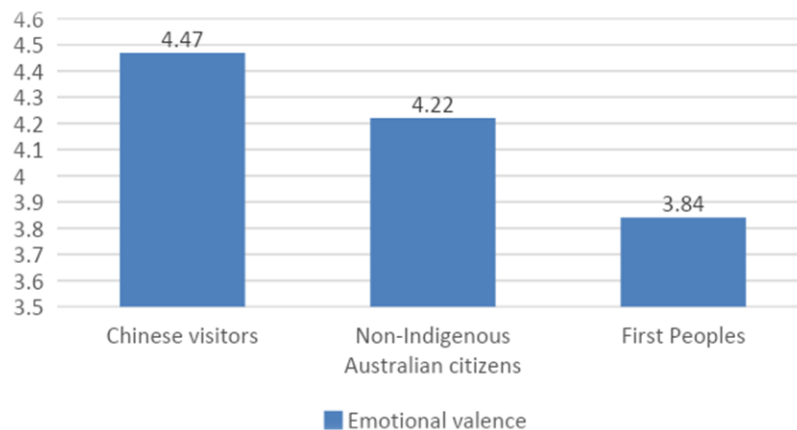
Figure 12: Self-report emotional valence (negative vs positive) to the GBR tourism video among the three groups

Chinese visitors and non-Indigenous Australian citizen participants demonstrated higher levels of positive attitudes towards the GBR as a tourism destination, potentially revealing their high intentions to visit the GBR. This quantitative study statistically confirms different views of GBR tourism among the three groups, which were found in the qualitative study (i.e., focus groups). First Peoples participants expressed less positive attitudes toward the GBR as a tourism

destination because they expected more responsible and culturally appropriate tourism development in the Reef regions (see Figure 13).
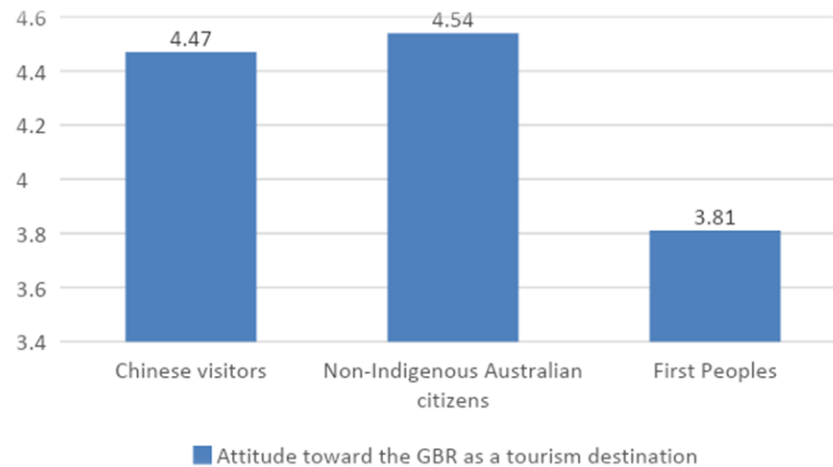
Figure 13: Attitudes towards the GBR as a tourism destination among the three groups

3.2.2 Relative contributions of objective versus subjective layers to aesthetic assessment

Statistical testing of aesthetic ratings among three groups enables researchers to verify the involvement and relative contributions of objective and subjective layers to the overall aesthetic assessment (objectives 2 & 3). If the subjective layer is superior, significant differences in aesthetic ratings among the three groups should be recorded in all environmental conditions of the GBR. If the objective layer is superior, three groups should generally agree on a similar aesthetic order of five GBR environmental conditions, and only marginal variances in aesthetic ratings among the three groups are recorded.

Contribution of the objective layer

In order to verify the contribution of the objective layer to overall aesthetic assessment of underwater GBR environments, we examined the average scores of aesthetic ratings (i.e., beauty and pleasantness) for the five GBR environmental conditions among the three groups. Figure 14 shows that the three Reef user groups shared a well-agreed aesthetic order of five GBR environmental conditions. Also, aesthetic judgement (i.e., beauty) and aesthetic emotion (i.e., pleasantness) of these five environmental conditions were highly aligned. The polluted scenes were rated the least beautiful. In contrast, the presence of human-made coral restoration structures in degraded Reef areas was associated with higher levels of pleasantness (approximate 7 on a 10-point scale) and a medium level in relation to aesthetic beauty (above 6). This suggests that all three groups appreciated human conservation efforts in restoring the GBR ecosystem and were dissatisfied by polluted scenery regardless of their socio-cultural differences. Further discussion of these two aesthetic measurement scales (beauty versus pleasantness) is provided in section 3.2.3.
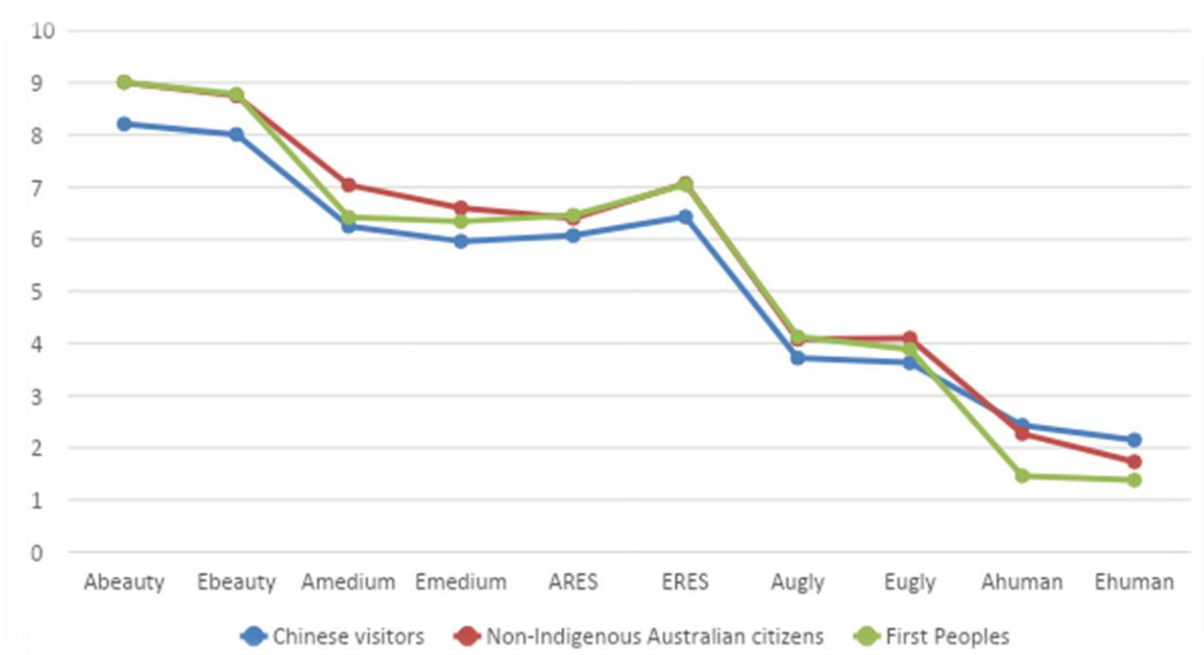
Figure 14: Average aesthetic scores for different environmental conditions of the GBR (aesthetic judgement and aesthetic emotions) among three groups

Note: *ABeauty– Average aesthetic judgement score for highly aesthetic scenery*
EBeauty – Average aesthetic emotion score for highly aesthetic scenery
AMedium – Average aesthetic judgement score for medium rated scenery
EMedium– Average aesthetic emotion score for medium rated scenery
ARES – Average aesthetic judgement score for coral restoration sites
ERES – Average aesthetic emotion score for coral restoration sites
AUgly – Average aesthetic judgement score for less aesthetic scenery
EUgly – Average aesthetic emotion score for less aesthetic scenery
AHuman – Average aesthetic judgement score for human-made elements in natural scenery (i.e. rubbish)
EHuman – Average aesthetic emotion scores for human-made elements in natural scenery (i.e. rubbish)

Contribution of the subjective layer

While the three groups agreed on the aesthetic order of five environmental conditions, significant differences were recorded in aesthetic ratings of highly aesthetic scenery on the one hand, and polluted scenery on the other hand (i.e. the extreme points of the scale). In contrast, aesthetic ratings of medium aesthetic, coral restoration and less aesthetic scenery were not significantly different (Table 5).

Table 5: ANOVA analysis to compare aesthetic ratings of the GBR among three groups for five environmental conditions

		Sum of Squares	df	Mean Square	F	Sig.
ABeautyM*	Between Groups	12.724	2	6.362	7.626	.001*
	Within Groups	75.088	90	.834		
	Total	87.812	92			
AHumanM*	Between Groups	19.408	2	9.704	8.779	.000*
	Within Groups	99.485	90	1.105		
	Total	118.892	92			
AMediumM	Between Groups	10.721	2	5.360	1.709	.187
	Within Groups	282.227	90	3.136		
	Total	292.948	92			
ARESM	Between Groups	2.724	2	1.362	.557	.575
	Within Groups	220.197	90	2.447		
	Total	222.921	92			
AUglyM	Between Groups	3.067	2	1.533	.609	.546
	Within Groups	226.515	90	2.517		
	Total	229.582	92			
EbeautyM*	Between Groups	11.923	2	5.962	5.936	.004*
	Within Groups	90.385	90	1.004		
	Total	102.308	92			
EHumanM*	Between Groups	9.122	2	4.561	5.706	.005*
	Within Groups	71.940	90	.799		
	Total	81.062	92			
EMediumM	Between Groups	6.121	2	3.061	.993	.374
	Within Groups	277.395	90	3.082		
	Total	283.516	92			
ERESM	Between Groups	8.290	2	4.145	1.460	.238
	Within Groups	255.510	90	2.839		
	Total	263.800	92			
EUglyM	Between Groups	3.457	2	1.728	.713	.493
	Within Groups	218.093	90	2.423		
	Total	221.550	92			

*Note: * Significant at 0.01*

The variance in aesthetic assessment among three groups suggests the involvement of a subjective aesthetic assessment layer. Further Tukey post-hoc tests (Table 6) show that differences in aesthetic assessment among three groups are significant, but mean differences of aesthetic ratings are less than 1 unit on 10-point Likert scale. It means that the subjective

layer based on socio-cultural meanings causes less than 10% of variations in aesthetic assessment. Therefore, it can be concluded that the objective layer is superior to the subjective layer in forming aesthetic assessment of GBR underwater scenery.

Table 6: Tukey post-hoc tests of mean differences among three groups

Dependent Variable	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
ABeautyM	Chinese	Australian	-.79140*	.23393	.003	-1.3489	-.2339
		First People	-.79115*	.23213	.003	-1.3443	-.2380
	Australian	Chinese	.79140*	.23393	.003	.2339	1.3489
		First People	.00025	.23019	1.000	-.5483	.5488
	First People	Chinese	.79115*	.23213	.003	.2380	1.3443
		Australian	-.00025	.23019	1.000	-.5488	.5483
AHumanM	Chinese	Australian	.00591	.26927	1.000	-.6358	.6476
		First People	.96458*	.26719	.001	.3278	1.6013
	Australian	Chinese	-.00591	.26927	1.000	-.6476	.6358
		First People	.95867*	.26495	.001	.3273	1.5901
	First People	Chinese	-.96458*	.26719	.001	-1.6013	-.3278
		Australian	-.95867*	.26495	.001	-1.5901	-.3273
EbeautyM	Chinese	Australian	-.74973*	.25665	.012	-1.3614	-.1381
		First People	-.78073*	.25467	.008	-1.3876	-.1738
	Australian	Chinese	.74973*	.25665	.012	.1381	1.3614
		First People	-.03100	.25255	.992	-.6328	.5708
	First People	Chinese	.78073*	.25467	.008	.1738	1.3876
		Australian	.03100	.25255	.992	-.5708	.6328
EHumanM	Chinese	Australian	.41613	.22897	.170	-.1295	.9618
		First People	.76719*	.22721	.003	.2257	1.3086
	Australian	Chinese	-.41613	.22897	.170	-.9618	.1295
		First People	.35106	.22531	.269	-.1859	.8880
	First People	Chinese	-.76719*	.22721	.003	-1.3086	-.2257
		Australian	-.35106	.22531	.269	-.8880	.1859

*. The mean difference is significant at the 0.05 level.

Note: *ABeauty– Average aesthetic judgement score for highly aesthetic scenery*
   EBeauty – Average aesthetic emotion score for highly aesthetic scenery
   AHuman – Average aesthetic judgement score for human-made elements in natural scenery (i.e. rubbish)
   EHuman – Average aesthetic emotion scores for human-made elements in natural scenery (i.e. rubbish)

More specifically, Chinese visitor participants rated the highly aesthetic GBR scenery at lower scores compared to non-Indigenous Australian citizens and First Peoples participants. Also, they gave higher aesthetic scores for images of polluted areas (i.e., presence of rubbish) than the two other groups. However, First Peoples participants expressed the opposite, in that they expressed a greater appreciation of the highly aesthetic GBR scenery (see Figure 15) and lower aesthetic evaluations of polluted scenery (see Figure 16).
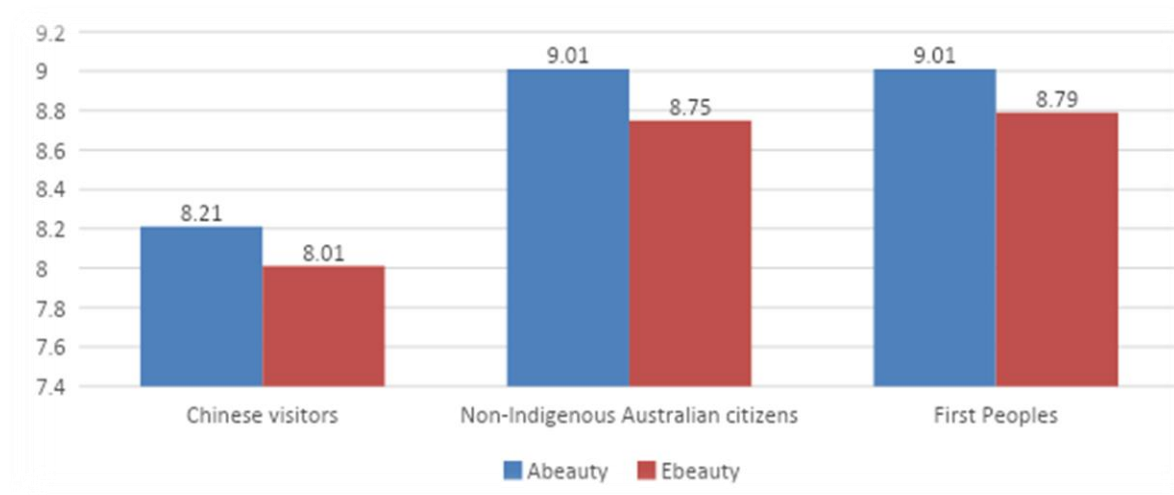
Note: *ABeauty – Average aesthetic judgement score for highly aesthetic scenery*
EBeauty – Average aesthetic emotion score for highly aesthetic scenery

Figure 15: Differences among the three groups in assessing beautiful Reef scenery (aesthetic judgement and aesthetic emotion)
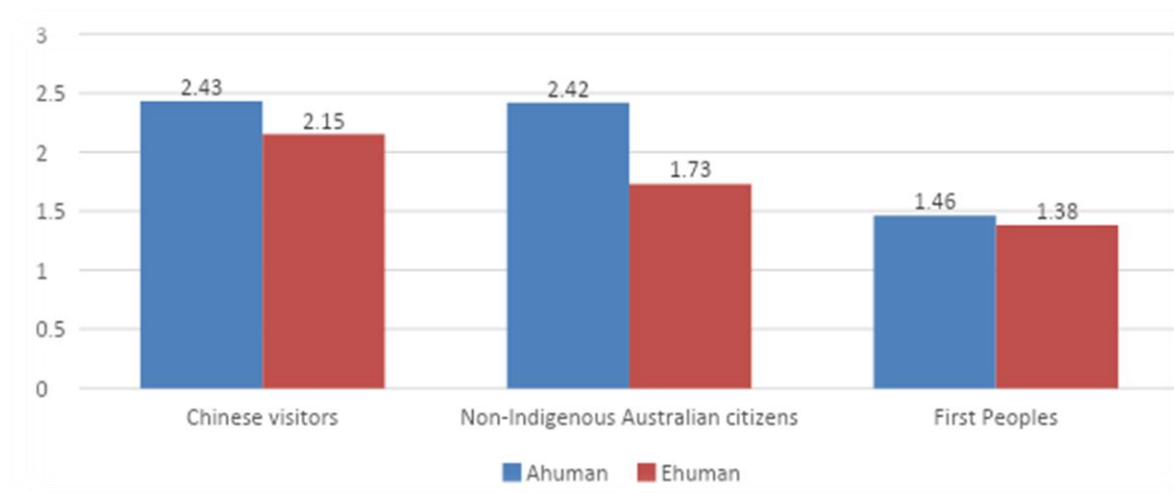
Note: *AHuman – Average aesthetic judgement score for human-made elements in natural scenery (i.e. rubbish)*
EHuman – Average aesthetic emotion scores for human-made elements in natural scenery (i.e. rubbish)

Figure 16: Differences among the three groups in assessing polluted Reef scenery (aesthetic judgement and aesthetic emotion)

3.2.3 Testing the validity of self-report, eye-tracking and face-reader measures

In order to address research objective 5, further analysis of self-report, eye-tracking and face-reader measures were conducted. The inclusion of two self-report aesthetic measurements (beauty and pleasantness) allows researchers to investigate the necessity of using two aesthetic measurements. As can be seen from Figure 14, the two measurement scales are highly correlated. Regression analysis for average scores of 93 participants for 20 images (Table 7) shows that aesthetic emotion (pleasantness) can explain up to 97% variances in aesthetic judgement (beauty): $\beta = 0.959$, $p < 0.001$. These outcomes justify that these two measurement scales can be used interchangeably in studying aesthetic assessment of natural environments. Further investigation of these aesthetic measurement scales should be tested in other content domains (e.g., art, design) to verify the validity of these two measurement scales.

Table 7: Regression outcome between aesthetic emotion and aesthetic judgement

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.301	.218		1.380	.184
	Aesthetic Emotion	.959	.036	.987	26.450	.000

a. Dependent Variable: Aesthetic Judgement

Following the initial testing of using eye-tracking in the NESP TWQ 3.2.3 project, eye-tracking was employed in the quantitative study to explore further how visual attention is related to aesthetic assessment. The average scores of eye-tracking measures (i.e., fixation duration, fixation count) for the total sample of 93 viewers were generated in correspondence to five environmental conditions. Fixation duration represents how much time a viewer spends observing the target object/image (i.e., fixation duration unit: second). Moreover, the fixation count reflects the number of times the viewer fixes their eye gaze on the target object/image (fixation count unit: number of fixations/ eye-gazes).

Eye-tracking data provide further evidence to support the objective layer of aesthetic assessment. Visual attention measured by eye-tracking (calculated for the 93 participants) is related to aesthetic assessment and does not differ among three groups (see Figure 17). Normally, it takes less than 3 seconds for an individual to view a picture and make an aesthetic assessment (Locher, Krupinski, Mello-Thoms, & Nodine, 2007). Participants might spend more time viewing an image through a deliberate (i.e., top-down) attentional process when they want to elaborate further on an image's content (Scott et al., 2019). Therefore, longer visual duration is likely to reflect a higher level of human aesthetic appreciation towards highly aesthetic GBR scenery and/or possibly viewers' interest in understanding the contents of coral images.
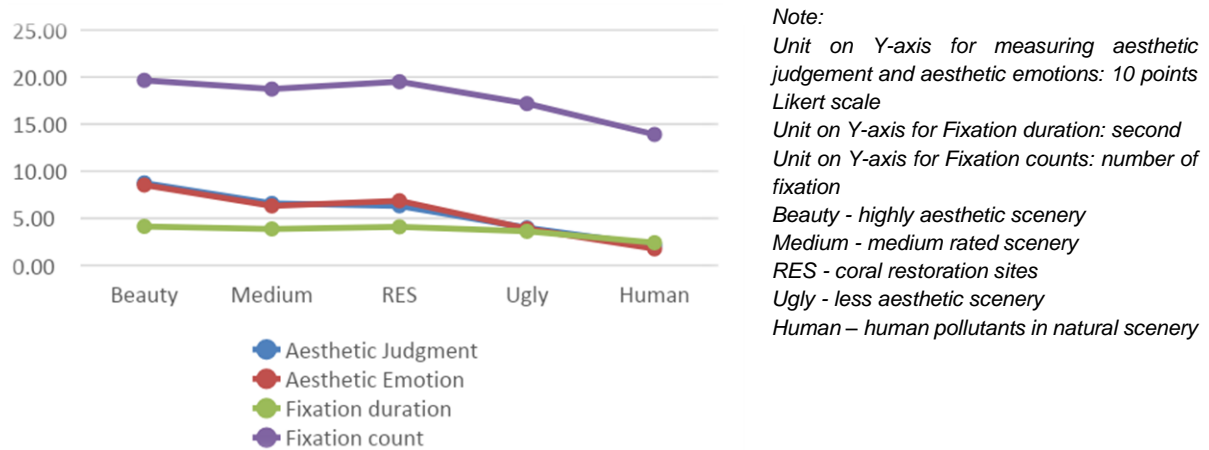
Note:
Unit on Y-axis for measuring aesthetic judgement and aesthetic emotions: 10 points Likert scale
Unit on Y-axis for Fixation duration: second
Unit on Y-axis for Fixation counts: number of fixation
Beauty - highly aesthetic scenery
Medium - medium rated scenery
RES - coral restoration sites
Ugly - less aesthetic scenery
Human – human pollutants in natural scenery

Figure 17: Average eye-tracking measures and aesthetic scores for five GBR environmental conditions

This study confirms the usefulness of eye-tracking in aesthetic research, demonstrating that eye-tracking measures (i.e., fixation duration, fixation count) can be used as indicators of human interest and aesthetic appreciation of GBR scenery. A series of regression models were performed to determine which eye-tracking measure reflects better human aesthetic assessment (Table 8). Based on the adjusted R square, fixation duration is a better indicator of human aesthetic assessment than fixation count for a cross-cultural sample.

Table 8: Single regression models of the aesthetic assessment using eye-tracking measures

Model	Model summary			Unstandardised coefficients	Coefficients Sig.
	Dependent variable	Adjusted R square	ANOVA sig.		
1. (constant) Fixation duration	Aesthetic judgement	0.514	0.000	0.717	0.218 0.000
2. (constant) Fixation count	Aesthetic judgement	0.485	0.001	0.696	0.088 0.001
3. (constant) Fixation duration	Aesthetic emotion	0.557		0.747	0.115 0.000
4. (constant) Fixation count	Aesthetic emotion	0.481	0.000	0.713	0.055 0.000

An ANOVA reveals no significant group differences related to viewers' visual attention (see Table 9). The eye-tracking data support the superior role of the objective aesthetic layer in forming aesthetic assessment because viewers' visual attention was consistently correlated to aesthetic ratings across three groups regardless of their socio-cultural differences.

Table 9: Differences in visual attention among three groups

	ANOVA				
		Sum of Squares	df	Mean Square	F	Sig.
FD_BeautyM	Between Groups	1042.693	2	521.346	1.086	.342
	Within Groups	43215.117	90	480.168		
	Total	44257.809	92			
FD_HumanM	Between Groups	555.179	2	277.590	1.586	.210
	Within Groups	15753.818	90	175.042		
	Total	16308.997	92			
FD_MediumM	Between Groups	399.685	2	199.842	.447	.641
	Within Groups	40202.812	90	446.698		
	Total	40602.497	92			
FD_RESM	Between Groups	1075.118	2	537.559	1.080	.344
	Within Groups	44791.344	90	497.682		
	Total	45866.462	92			
FD_UglyM	Between Groups	2323.318	2	1161.659	4.416	.015
	Within Groups	23677.180	90	263.080		
	Total	26000.498	92			
FC_BeautyM	Between Groups	211.261	2	105.631	1.176	.313
	Within Groups	8086.256	90	89.847		
	Total	8297.517	92			
FC_HumanM	Between Groups	52.745	2	26.372	.429	.653
	Within Groups	5533.660	90	61.485		
	Total	5586.405	92			
FC_MediumM	Between Groups	265.832	2	132.916	.978	.380
	Within Groups	12227.726	90	135.864		
	Total	12493.558	92			
FC_RESM	Between Groups	196.007	2	98.004	.893	.413
	Within Groups	9880.115	90	109.779		
	Total	10076.122	92			
FC_UglyM	Between Groups	68.100	2	34.050	.407	.667
	Within Groups	7526.098	90	83.623		
	Total	7594.198	92			

Note: FD_BeautyM – Average fixation duration for highly aesthetic scenery
FD_MediumM – Average fixation duration for medium rated scenery
FD_RESM – Average fixation duration for coral restoration sites
FD_UglyM – Average fixation duration for less aesthetic scenery
FD_HumanM – Average fixation duration for human-made elements in natural scenery (i.e. rubbish)

FC_BeautyM – Average fixation counts for highly aesthetic scenery
FC_MediumM – Average fixation counts for medium rated scenery
FC_RESM – Average fixation counts for coral restoration sites
FC_UglyM – Average fixation counts for less aesthetic scenery
FC_HumanM – Average fixation counts for human-made elements in natural scenery (i.e. rubbish)

Furthermore, face-reader technology was utilised to measure simultaneous emotional responses to the GBR promotion video. Participants' facial movements were captured using a webcam and then analysed by FaceReader™ by generating standardised z-scores representing emotional valence and emotional arousal for each participant (see picture 3). FaceReader™ log data was exported to an excel sheet and then used for performing ANOVA analysis. Face-reader also provided similar data as self-report measures that confirm significant differences in emotional valence (positive versus negative) among three groups (see Table 10). ANOVA results demonstrate the significant differences *(p< 0.05)* in emotional valence between the three groups (within-subject comparison).

Table 10: Differences in emotional valence (negative vs positive) in responses to the GBR promotional video among the three groups as measured by Face-reader (z-score)

		Sum of Squares	df	Mean Square	F	Sig.
Emotional valence	Between Groups	.269	2	.134	3.927	.023
	Within Groups	3.249	95	.034		
	Total	3.517	97			

ANOVA

4.0 DISCUSSION

This report advances our understanding of how socio-cultural characteristics influence aesthetic assessment of natural environments. Findings from the two studies are further elaborated in this section to address each research objective before discussing practical implications.

4.1 Socio-cultural background – objective 1

Three Reef user groups (i.e., Chinese visitors, non-Indigenous Australian citizens, First Peoples) were recruited in two studies based on the assumption that they have different socio-cultural characteristics related to the GBR.

In Study 1, focus group discussions illustrated that Chinese visitors and non-Indigenous Australian citizen participants viewed the GBR aesthetics from a visitor perspective whilst First Peoples had a spiritual and cultural connection with the Reef. Chinese visitor participants were less familiar with water-related experiences such as diving or snorkelling and more interested in helicopter or boat tours for viewing the GBR aesthetics from above-water view. Moreover, Chinese visitor participants mainly considered the GBR as a famous tourism destination in Australia. Non-Indigenous Australian citizen participants and First Peoples were more concerned about the fragility of the GBR under climate change and tourism pressures.

Study 2 statistically confirmed socio-cultural differences among the three groups. First Peoples had the highest levels of self-report knowledge and experience with the GBR, followed by non-Indigenous Australia citizens and then Chinese visitor participants. Also, Chinese visitor participants had the lowest levels of diving/snorkelling experiences compared to other two groups, confirming their unfamiliarity with water-related experiences. When viewing the GBR tourism promotion video, Chinese visitor participants expressed more positive emotions and positive attitude toward the GBR as a destination.

4.2 A dual-perceptual approach – objectives 2 & 3

Research findings from Study 1 and Study 2 on objective and subjective layers of aesthetic assessment provide empirical evidence to support the application of a dual-perceptual approach. The academic debate between researchers applying the subjective versus objective approach leads to complex and somehow contradictory conclusions on how people perceive the aesthetic value of natural environments (Adevi & Grahn, 2012). The dual-perceptual approach offers a more comprehensive model to understand aesthetic assessment by reconciling an objective aesthetic layer based on environmental characteristics and a subjective aesthetic layer based on socio-cultural interpretation/meanings. The dual-perceptual model (Figure 18) can explain when and why people agree or disagree on the aesthetic value of underwater GBR environments.
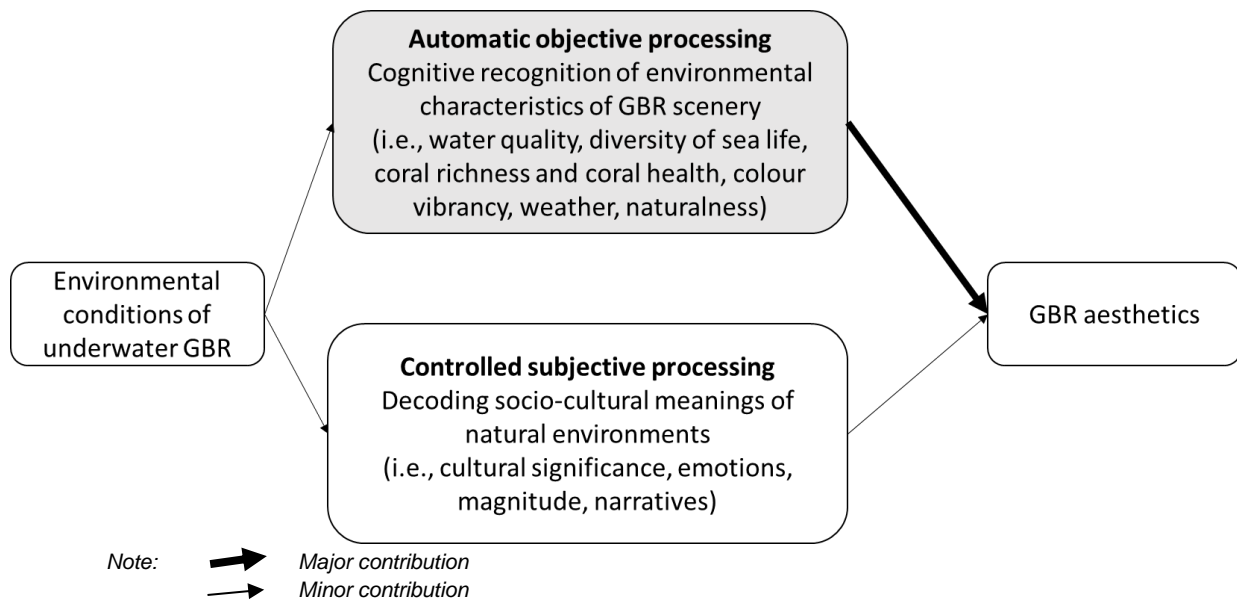
Note: → Major contribution
       → Minor contribution

Figure 18: Relative contributions of objective versus subjective layer to the overall aesthetic assessment of underwater GBR scenery

Statistical testing of aesthetic ratings in Study 2 clarifies the relative contributions of the objective versus subjective layer to the overall aesthetic assessment. Content domains and/or aesthetic targets will determine which aesthetic layer is dominant (Jacobsen, 2010). In art and design areas, the subjective layer based on the interpretation of socio-cultural meanings attached to artistic objects/ masterpieces might be superior to the objective layer (Leder & Nadal, 2014). Meanwhile, our research demonstrates that the objective layer seems to dominate the subjective layer when people aesthetically evaluate natural environments, at least in the case of under-water scenery. Three groups with different socio-cultural characteristics agreed on an aesthetic order of five environmental conditions of the GBR. Also, their visual attention to each scenery was similar and consistently correlated with their aesthetic ratings.

The involvement of the subjective layer in aesthetic rating of the GBR underwater scenery is recorded at a low level. First Peoples appeared to attach cultural significance and spiritual connections to the GBR and thus appreciate the scenic beauty of the GBR more than other groups. Subsequently, First Peoples were likely to be more sensitive to environmental changes in the Reef scenery and more disturbed by polluted Reef areas. The variances in aesthetic ratings in both cases were less than 1 unit on a 10-point aesthetic scale (i.e. 10%).

It can be concluded that the objective aesthetic layer based on environmental characteristics make a more significant contribution to the overall aesthetic assessment of the GBR underwater scenery (see Figure 18). Our research outcomes are consistent with some other studies that individuals tend to achieve highly convergent aesthetic ratings of natural environments regardless of their different expectations and cultural knowledge about the place (McAndrew, Turner, Fiedeldey, & Sharma, 1998; Petrova et al., 2015). People seem to have convergent aesthetic assessments when evaluating natural environments than when appreciating the artefacts of human cultures (Vessel, Maurer, Denker, & Starr, 2018).

4.3 The role of human elements – objective 4

In this research, we included two groups of images containing human-made elements (i.e., rubbish and coral restoration structures) to investigate how human-made elements influence people's aesthetic assessment of Reef environments (see sections 3.1.2 and 3.2.2). The results show that the influences of human-made elements on aesthetic assessment are significantly related to personal interpretation of the positive versus negative impacts of these elements on the environment. Images of coral restoration sites are ranked in the middle of the aesthetic scale because participants appreciate the positive intention of restoring the Reef. Also, these coral restoration structures are related to positive emotions of hope for a better future. For example, participant 4 (non-Indigenous Australian citizen, 18-25 years, female) commented: "*I understand that it might not look good now. Hopefully, it looks better later, but more for the coral restoration, as long as while they're also restoring it's on with the sustainability and preserving*". In contrast, the presence of human "footprints" such as plastic bags or rubbish in the ocean is often related to negative emotions of unpleasantness and lowest aesthetic scores (see Figure 14).

4.4 Methodological insights – objective 5

The current research investigated the usefulness of advanced research technologies (i.e., eye-tracking, face-reader) in addition to self-report measures to investigate aesthetic assessment (see section 3.2.3). Self-report methods are widely used in aesthetic research because they are simple and easy to use/analyse. However, the biggest disadvantage of using self-report methods is related to human bias. For example, respondents from different cultural backgrounds often have different responses styles of respondents, which may cause misinterpretation of research findings (Dolnicar & Grün, 2007). In contrast, physio-psychological measurements such as eye-tracking and face-reader offer more objective measures of participants' responses to stimuli. However, these research methods require more time and effort in data collection and data analysis (Li, Scott, & Walters, 2015; Scott et al., 2017). A summary of the advantages and disadvantages of these methods is presented in Table 11.

Table 11: Advantages and disadvantages of various research methods

Methods	Measured construct	Advantages	Disadvantages
Self-report Aesthetic judgement (beauty) Aesthetic emotion (pleasantness)	Aesthetic assessment	Easy to use; Useful for group comparison	Bias in survey completion
Eye-tracking	Visual attention (i.e., interest)	Objective measure; correlates to beauty rating	Complexity in data collection and data analysis
Face-reader	Emotions	Ability to measure simultaneous emotional responses to the stimulus; provides additional factors that might affect subjective layer of assessment	Limited use for emotional responses to images Complexity in data collection and data analysis

Regarding self-report methods, an additional scale of aesthetic emotion (i.e. pleasant/unpleasant) was included in addition to the traditional measurement scale of beauty. Many measurement scales have been used to study aesthetic preference of natural environments, but aesthetic judgement (ugly/beautiful) is the most widely used (Curnock et al., 2020). In this research, aesthetic emotion of pleasantness was found to be highly correlated with aesthetic judgement of beauty. Hence, this research suggests future aesthetic research can rely on the beauty scale to measure aesthetic assessment effectively.

In comparison with self-report, eye-tracking and face-reader are useful in measuring participants' simultaneous responses, whilst limiting human bias. The use of eye-tracking provides further evidence to support the relationship between visual attention as an objective measure of interest and aesthetic assessment. The use of eye-tracking in tracking aesthetic assessment in underwater conditions may be difficult at present (due to the equipment design). However, eye-tracking technology can be applied in future aesthetic research inland or indoor environments such as exhibitions or museums and potentially have some implications for monitoring the aesthetic beauty of above-water landscapes (Scott et al., 2017). Indeed, face-reader was used to measure participants' emotions in response to the GBR promotional video and provides consistent outcomes with self-report measurement. It suggests that face-reader can provide useful insights in investigating emotional responses when it is impractical to collect self-report answers (Hadinejad, Moyle, Kralj, & Scott, 2019).

4.5 Practical implications for managing the aesthetic value of the GBR

Based on a better understanding of how people perceive Reef beauty, several recommendations can be made. Effective communication with various Reef user groups could benefit from understanding nuances in aesthetic assessment (e.g., what kind of imagery appeals to what type of group and what kind of emotions it might trigger).

First, when collecting aesthetic ratings from people (e.g. professionals, visitors, citizens), reef managers can feel confident that objective attributes dominate. The influence of the subjective layer still exists but the impact seems relatively limited (less than 10%). Therefore, with a reasonable sample for aesthetic ratings (100 people/image), the aesthetic score can be representative for various Reef user groups regardless of their socio-cultural backgrounds (Curnock et al., 2020; Pert, Thiault, Curnock, Becken, & Claudet, 2020). This also makes it more appealing to use a computer-based system (e.g. neural network and machine learning based) to capture this objective layer and rate large volumes of images. Big data and machine-based systems could present a cost-effective aesthetic monitoring management tool (Becken et al., 2018). Further results on such a system will be presented separately as part of the NESP TWQ 5.5. project. Socio-cultural differences in aesthetic ratings can be considered as an acceptable variance when using the aesthetic monitoring AI system (Haas et al., 2015). Obviously, it will be beneficial to conduct further research to refine and improve the aesthetic monitoring AI system based on understanding the socio-cultural interpretation and meanings of the GBR from different reef user groups' perspectives.

Second, when the Reef ecosystem has been consistently challenged by climate change effects and the increasing number of coral bleaching events, drawing upon Indigenous traditions and cultural aspects is potentially a promising strategy to communicate the GBR aesthetics – and as a result, increase public awareness of the need to protect it. Landscapes of cultural significance are often considered as having high aesthetic value (Bourassa, 1990; Nohl, 2001) and a better understanding of the socio-cultural meanings of a place might improve visitors' aesthetic appreciation (Hull & Reveli, 1989; Yu, 1995). First Peoples communities have a long history of stewardship of country and as a result, hold special connections with the land and the reef. Indigenous stories lines, songs and dances reflect community attachment to country and become the soul of their living places. Feedback obtained on a draft version of this report highlights this. Gerry 'Iljiddimor' Surha is a Jiddabal/Mandubarra/Yidinji man and his mob are rainforest and saltwater people from far north Queensland. Gerry is advocating for a nationwide education program that draws on Indigenous knowledges that have kept our planet safe for 65,000 years. Gerry said that "the decline of the reef has shaken his mob to the core". He warns that the environment and the Reef in particular, is at the tipping point and that we need to act now to protect the reef as it is his home. Gerry warned that we need to stop talking about what we are going to do and actually do something now before it's too late and environmental action has to come from all Australians. "We need to work in unity to save the reef and set a precedent for all environmental action now and into the future". This is elaborated by Dewaynne Mundraby who provides a Mandingalbay Yidinji perspective and notes that "What's important is preservation and rehabilitation to ensure the cultural story lines continue, transmission of knowledge, mixing culture and science in the interest of generations to come".

Finally, to foster the practice of responsible behaviour, GBR communication messages could be customised toward different Reef user groups. For example, Chinese visitors to Australia are less aware of environmental change within the Reef areas and thus may have higher expectations of Reef aesthetics. They are also less familiar with water-related experiences (i.e., diving, snorkelling) and are more likely to appreciate above-water Reef aesthetics (i.e., boat tour, helicopter tour). Therefore, GBR-related messages targeting a Chinese audience should present the GBR aesthetics from aerial and above-water views, such as those seen through glass bottom boats. Moreover, safety is a critical factor that enables Chinese visitors

to enjoy their aesthetic Reef experiences. By showing how Australian companies comply with high safety standards for visitors, tour operators in the Reef regions can build a safe image of the GBR and enhance visitor enjoyment and appreciation.

Indeed, emotion-focused messages will be more effective when targeting domestic visitors (i.e., non-Indigenous Australian citizens and First Peoples). As Indigenous and non-Indigenous Australian citizens are well aware of environmental changes in the Reef regions, messages containing emotional appeals of fear (Hartmann, Apaolaza, D'souza, Barrutia, & Echebarria, 2014), guilt or anger (Harth, Leach, & Kessler, 2013) and anxiety (Kapeller & Jäger, 2020) can be effective in motivating pro-environmental behaviour. The emotional appeals should be accompanied by specific actions to protect the reef (e.g., recycling, donating for coral restoration, etc.) to also elicit positive emotions (e.g., hope) and empower individuals to see how they can change their behaviour. Connecting aesthetic imagery with environmental information is important and could inform work by relevant organisations, for example GBRMPA and TEQ who already support/promote eco-friendly tour operators and accommodation providers.

5.0 LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

This report makes significant contributions to extend our understanding Reef aesthetics, but there are some limitations that should be addressed in future studies. First, different research methods (eye-tracking, face-reader, self-report) were employed, but these methods remain limited to visual aesthetic assessment. Therefore, other sensory aspects of aesthetic experiences and aesthetic appreciation should be further explored in future studies (Curnock et al., 2020). Ideally, researchers should employ face-reader and eye-tracking to explore visitors' aesthetic experiences in real-life conditions. Second, participants in our research are biased toward younger cohorts (mostly under 35). Some conclusions may not be generalised for older members of the population. Hence, it is beneficial to verify the dual-perceptual model with other samples. Third, this research focuses only on aesthetic assessment without directly studying its influences on pro-environmental behaviour. Even though the current literature suggests that aesthetic appreciation inspires conservation behavioural intentions, it will be beneficial to further explore this relationship in the context of the GBR and explore psychological mechanisms behind it.

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APPENDIX 1: PROFILE OF PARTICIPANTS IN THE FOCUS GROUPS

Groups	ID	Age	Gender
Non-Indigenous Australian citizens	Participant 1	18-25 years	Male
	Participant 2	18-25 years	Female
	Participant 3	35-45 years	Male
	Participant 4	18-25 years	Female
	Participant 5	18-25 years	Female
	Participant 6	18-25 years	Male
	Participant 7	18-25 years	Female
Chinese visitors	Participant 8	18-25 years	Female
	Participant 9	18-25 years	Female
	Participant 10	18-25 years	Male
	Participant 11	18-25 years	Female
	Participant 12	18-25 years	Female
	Participant 13	18-25 years	Female
	Participant 14	18-25 years	Male
	Participant 15	18-25 years	Male
First Peoples	Participant 16	25-35 years	Female
	Participant 17	25-35 years	Male
	Participant 18	35-45 years	Female
	Participant 19	Over 45 years	Male
	Participant 20	35-45 years	Female
	Participant 21	25-35 years	Male
	Participant 22	25-35 years	Female
	Participant 23	25-35 years	Female
	Participant 24	18-25 years	Male
	Participant 25	25-35 years	Male
	Participant 26	Over 45 years	Male
	Participant 27	25-35 years	Male
	Participant 28	35-45 years	Female
	Participant 29	Over 45 years	Female

APPENDIX 2: QUESTIONNAIRE USED IN THE EYE-TRACKING AND FACE-READER EXPERIMENT

Investigating beauty and experience values of the Great Barrier Reef
This research explores how ecological changes affect the beauty and the user experience of the Great Barrier Reef. You will be asked about your knowledge, experiences, attitude and aesthetic assessment of the Great Barrier Reef (GBR). You will also view some pictures of the GBR underwater scenery and express your opinion about them. it would take you about 10 minutes for completion.
Your information will be confidential, and your participation will remain anonymous.
Completion of this survey will be taken as your consent to participate in the research.
Please click the mouse to continue when you are ready!

SECTION 1: DEMOGRAPHIC QUESTIONS
Q1. Please indicate your age
1. Under 25 years old
2. 26-35 years old
3. 36-45 years old
4. 45+

Q2. Please indicate your gender
1. Male
2. Female
3. Other

Q3. Do you affiliate as ...
1. Chinese
2. Non-Indigenous Australian resident or citizen
3. First Peoples

Q4. Have you been to the Great Barrier Reef before?
1. Never
2. 1-2 times
3. 3-4 times
4. Over 4 times

Q5. How much do you know about the Great Barrier Reef?
1. Not at all
2. A little
3. A moderate amount
4. A lot
5. A great deal

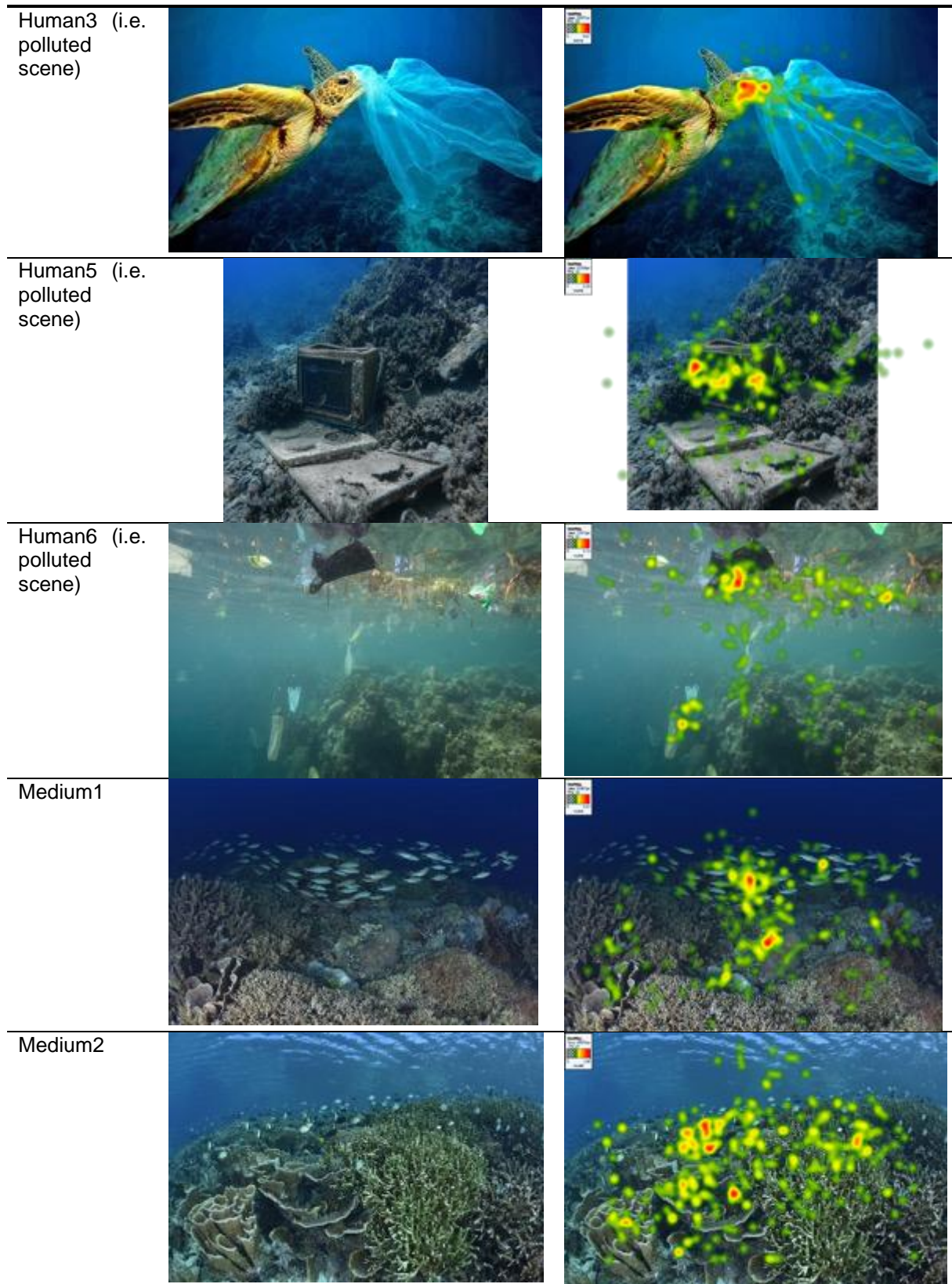Q6. Have you had any diving/snorkelling experiences in the ocean?
1. Never
2. 1-2 times
3. 3-4 times
4. Over 4 times

SECTION 2: PICTURE RATINGS

You are going to look at the pictures of underwater scenes of the Great Barrier Reef and rate the beauty of each picture. You can look at each picture as long as you want and then click the mouse to move to the beauty rating questions.

Please click the mouse when you are ready!

Participants viewed 16 selected images in random order and answered two questions after viewing each image.

Q1. Please rate the beauty of this image from 1 (Extremely ugly) to 10 (Extremely beautiful).

Q2: Please rate your emotions towards this image from 1 (Extremely unpleasant) to 10 (Extremely pleasant)

SECTION 3: GBR TOURISM

You are going to watch a video of the Great Barrier Reef and answer some questions.

Please click the mouse when you are ready!

Q1. Please indicate how you felt while watching the video.
1. Very sad
2. Sad
3. Neutral
4. Happy
5. Very happy

Q2. Please provide an indication of how much you felt excitement, joy, wonder, amazement, or surprise while watching the video.
1. Not at all
2. A little
3. A moderate amount
4. A lot
5. A great deal

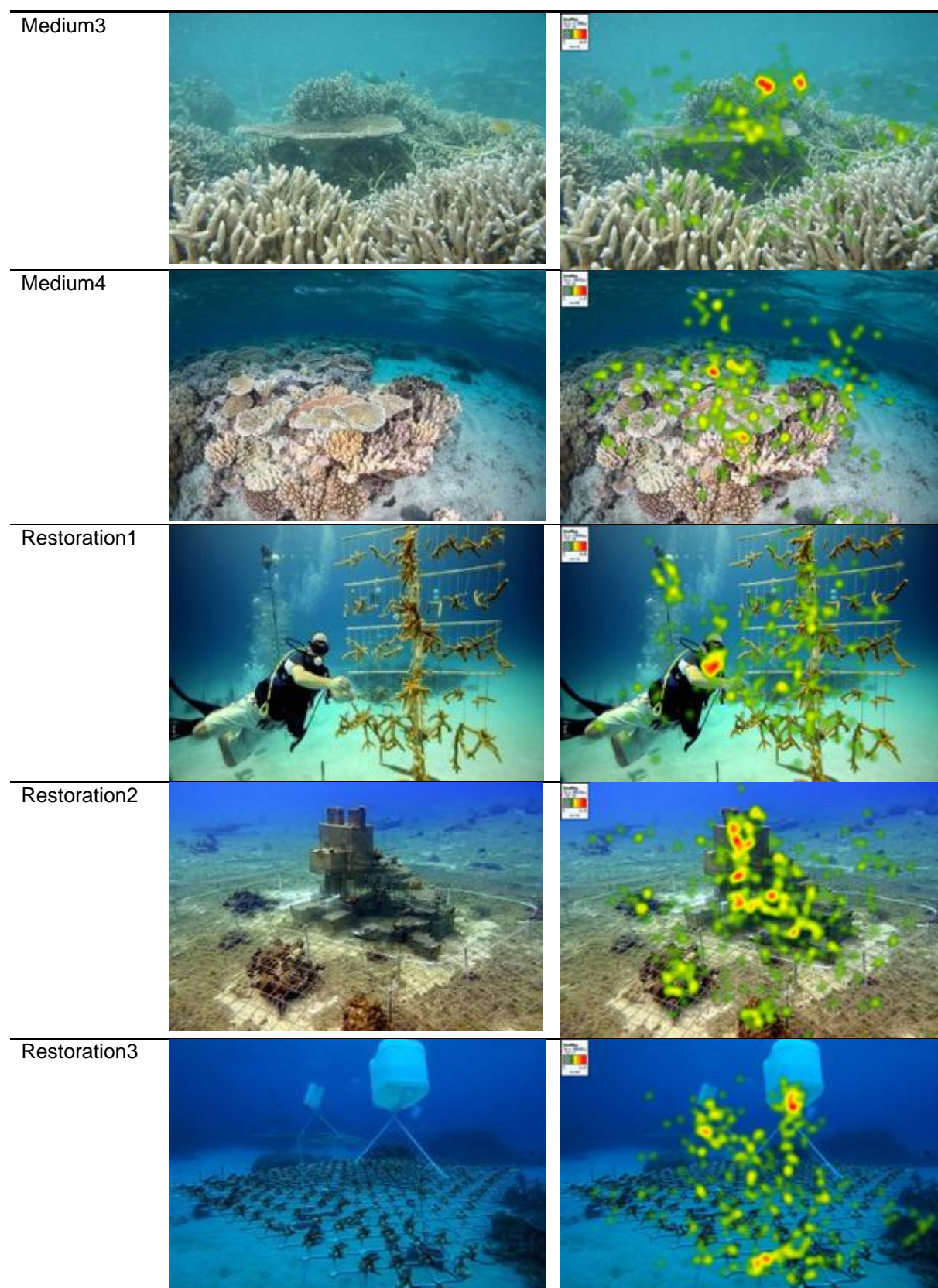Q3. How is your overall attitude towards the Great Barrier Reef as a tourism destination?
1. Unfavourable
2. Somehow unfavourable
3. Neutral
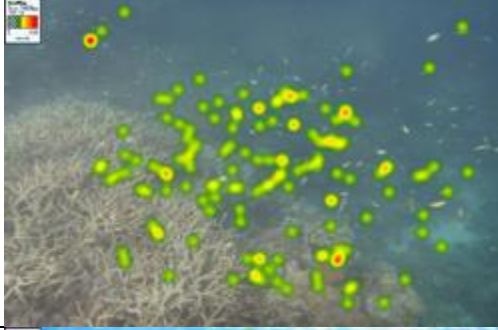4. Somehow favourable
5. Favourable

Thank you very much for your participation! We highly appreciate your time and support.

APPENDIX 3: THE 20 ORIGINAL PICTURES USED IN THE EYE-TRACKING EXPERIMENT AND HEATMAPS GENERATED

Name	Original image	Heatmap
Beauty1		
Beauty2		
Beauty3		
Beauty4		
Human1 (i.e. polluted scene)		

Human3 (i.e. polluted scene)		
Human5 (i.e. polluted scene)		
Human6 (i.e. polluted scene)		
Medium1		
Medium2		

Medium3	
Medium4	
Restoration1	
Restoration2	
Restoration3	

Restoration8		
Ugly1		
Ugly2		
Ugly3		
Ugly4		